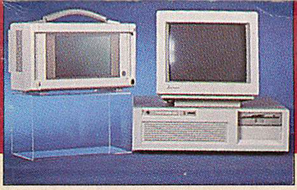
PORTABLE 386 FROM COMPAQ

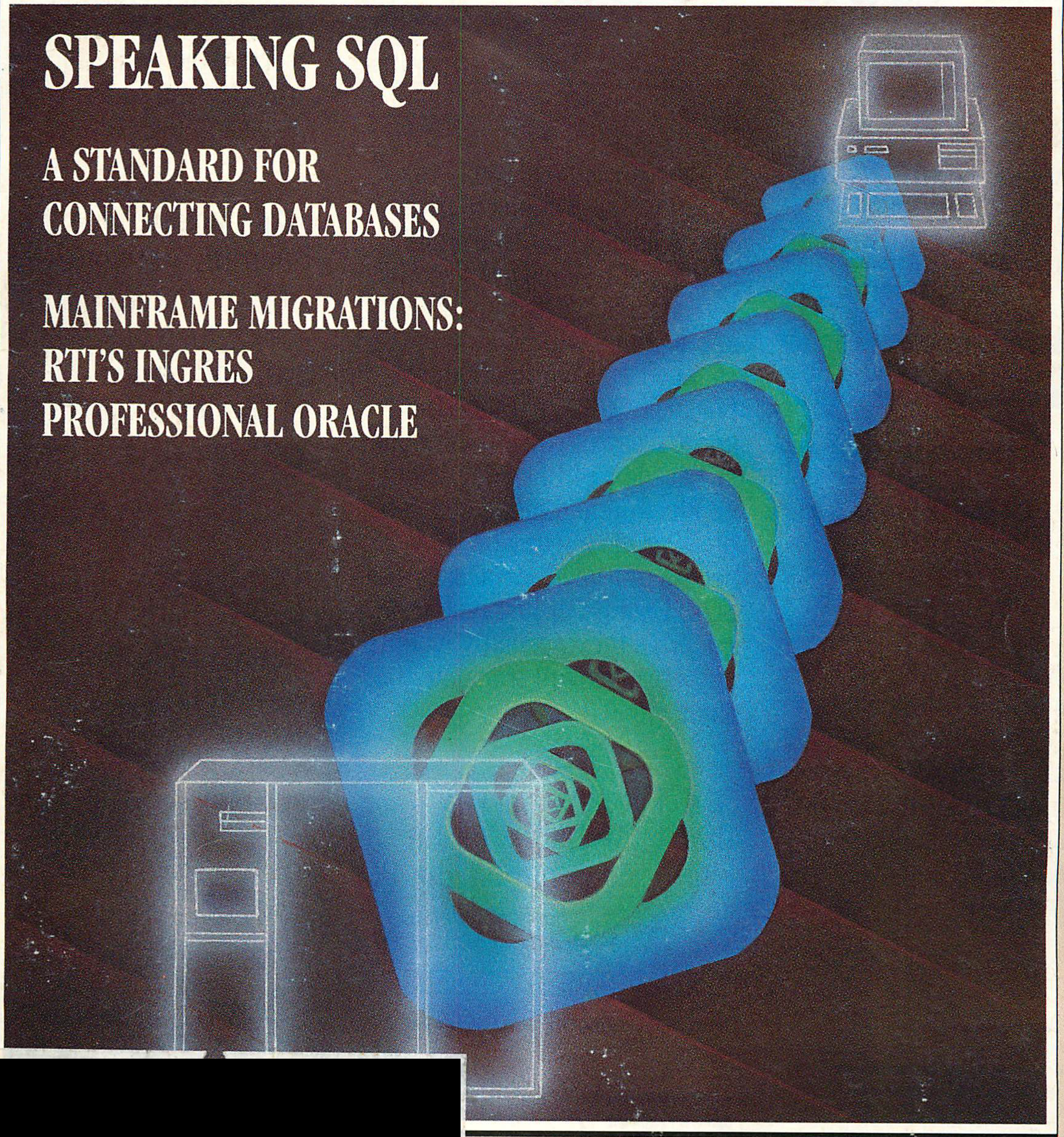


386 FROM PC'S LIMITED

DECEMBER 1987 VOL. 5 NO. 12 $3.95

# PC TECH JOURNAL®

FOR SYSTEMS DEVELOPERS AND INTEGRATORS

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# Why Parad

"Paradox® is once again the top-rated program, with the latest version scoring even higher than last year's top score." (Software Digest's July 1987 Ratings Report—an independent comparative ratings report for selecting IBM PC Business software).

All tests for the Ratings Report were done by the prestigious National Software Testing Laboratory, Philadelphia, PA, and the message is crystal clear: there is no better relational database manager than Paradox.

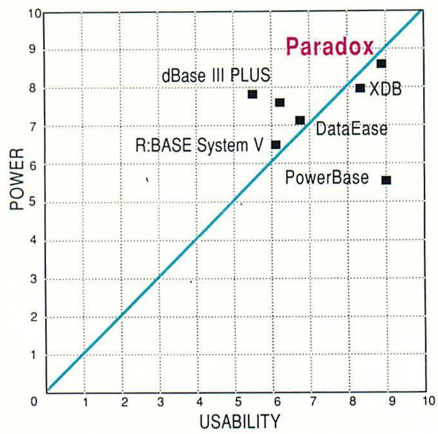
NSTL tested 12 different programs and amongst other results, discovered that Paradox is 3 times faster than dBASE; 6 times faster than R:BASE on a two-file join with subtotals test†.

## *Paradox does the impossible: combines ease-of-use with power and sophistication*

Even if you're a beginner, Paradox is the only relational database manager that you can take out of the box and begin using right away.

Because Paradox employs state-of-the-art artificial intelligence technology, it does almost everything for you—except take itself out of the box.

If you've ever used 1-2-3® or dBASE®, you already know how to use Paradox. It has Lotus-like menus, and Paradox documentation includes "A Quick Guide to Paradox for Lotus users," and "A Quick Guide to Paradox for dBASE users."




*Source: Software Digest**

*Ideal programs have high levels of both power and usability. Programs plotted in the upper righthand portion of the diagram above come closest to achieving that ideal.*

> "Paradox still offers superior import/export facilities using Lotus 1-2-3, dBASE, ASCII and other file types. It transfers between formats with stunning speed"
>
> *Rusel DeMaria, PC Week*

## *Paradox responds instantly to "Query-by-Example"*

The method you use to ask questions is called Query-by-Example. Instead of spending time figuring out *how* to do the query, you simply give Paradox an example of the results you're looking for. Paradox picks up the example and automatically seeks the fastest way of getting the answer. Paradox, unlike other databases, makes it just as easy to query multiple tables simultaneously as it is to query one.

*Source: Software Digest**

| Software Digest Rating | Overall Evaluation | Program Name | Version Tested | Ease of Learning | Ease of Use | Error Handling | Performance | Versatility | Memory Requirement | Price |
|---|---|---|---|---|---|---|---|---|---|---|
| ☆☆☆☆ | 8.7 | Paradox | 1.1 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 512K | $495 |
| ☆☆☆☆ | 8.2 | XDB | 1.10 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 320K | $750 |
| ☆☆☆ | 7.6 | PowerBase | 2.3 | 🟦 | 🟦 | 🟦 | 🟨 | 🟥 | 384K | $349 |
| ☆☆☆ | 7.0 | Open Access II | 2.0 | 🟨 | 🟨 | 🟦 | 🟦 | 🟦 | 256K | $395 |
| ☆☆☆ | 7.0 | DataEase | 2.5/2 | 🟦 | 🟦 | 🟥 | 🟦 | 🟦 | 384K | $600 |
| ☆☆ | 6.6 | dBASE III PLUS | 1.1 | 🟨 | 🟨 | 🟦 | 🟦 | 🟨 | 384K | $695 |
| ☆☆ | 6.4 | R:BASE System V | 1.1 | 🟨 | 🟨 | 🟦 | 🟥 | 🟦 | 512K | $700 |

RATINGS KEY
(On a scale of 0 to 10)
Overall Evaluation

☆☆☆☆☆ 9.0 or higher
☆☆☆☆ 8.0 - 8.9
☆☆☆ 7.0 - 7.9
☆☆ 6.0 - 6.9
☆ 5.0 - 5.9

All Other Ratings

🟦 7.0 - 9.9
🟨 5.0 - 6.9
🟥 UNDER 5.0

# x is the best

*There's no power like Paradox Power*

| PROGRAM | Overall Power | Overall Performance | Overall Versatility | Single-Record Search (sec.) | Indexed Group Record Search (sec.) | Search without an Index (sec.) | Subtotal 100 Groups (sec.) | Subtotal on Two-File Join (sec.) | Three- File Join (sec.) | Subtotal on Three-File Join (sec.) | Four-File Join (sec.) | Many-to-Many Join (sec.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Paradox | 8.4 | 9.2 | 7.5 | 1.0 | 6 | 100 | 221 | 325 | 459 | 364 | 322 | 18 |
| dBASE III PLUS | 7.9 | 8.9 | 6.9 | 0.5 | 17 | 93 | 525 | 1013 | 646 | 449 | 445 | 39 |

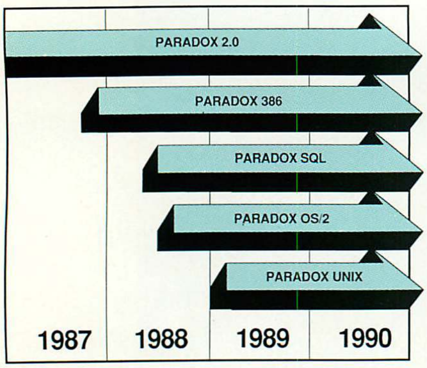
*Source: Software Digest**

## *Paradox makes your network run like clockwork*

Paradox is just as valuable to multi and network users as it is to single users. It runs smoothly, intelligently and so transparently that multiusers can access the same data at the same time—without either being aware of each other or getting in each other's way. It works exactly the same way whether you're flying solo or as part of the crew.

## *Paradox saves you from future shock*

**Trends for the future with Paradox**




Paradox 386 allows users to take advantage of 16 Megabytes of Memory on a 386 machine. This allows Paradox users to work with databases that could in the past only be handled by minicomputers and mainframes.

Your investment today in Paradox applications is protected as new hardware and operating systems are used in your company. Paradox 2.0 applications will run unchanged on Paradox 386, Paradox OS/2, Paradox Unix and Paradox SQL! All versions of Paradox will be completely application and menu compatible. Paradox SQL will allow access to remote databases via SQL. Users will just type in a query as they normally would, and Paradox will translate that Query to SQL.

“Paradox 2.0 will do for the LAN what the spreadsheet did for the PC

*David Schulman,*
*Bendix Aerospace* ”

“Anyone who hasn't seen the network version of Paradox should take a look. Ansa has dramatically advanced the state of the art in multiuser network databases

*Phil Lemmons,*
*BYTE*

Paradox was a delight to use, both as a stand-alone product and from a local area network server.

*Don Crabb,*
*InfoWorld* ”

***How to make your network network***

The Paradox Network Pack can be installed only on a network. To run Paradox 2.0 or the Paradox Network Pack on a network, you need:

- Novell with Novell Advanced Netware version 2.0A or higher
- 3Com 3Plus with 3Com 3+ operating system version 1.0, 1.1 or higher
- IBM Token Ring or PC Network with IBM PC Local Area Network Program version 1.12 or higher
- Torus Tapestry version 1.4 or higher
- AT&T Starlan Network with AT&T PC 6300 Network Program version
- Other network configurations that are 100% compatible with DOS 3.1 and one of the listed networks

***System Requirements for Single User:***

- DOS 2.0 or higher
- IBM® PS/2 and PC, Compaq® PC families and other 100% compatibles
- 512K RAM
- Two disk drives, 3½-inch and 5¼-inch supported
- Compatible monochrome, color, or EGA monitor with adapter

***System Requirements for the Network Workstation:***

- DOS 3.1 or higher
- 640K RAM
- Any combination of hard, floppy, or no disk drives
- Compatible monochrome, color, or EGA monitor with adapter

***Optional Equipment:***

- EMS and EEMS Boards: AST RAMpage Board,™ Intel Above Board® or other expanded memory adapters
- Printers: Compatible dot matrix, letter quality, or laser printer

*†Test was designed and executed by NSTL. A 1,000-record and a 10,000-record file were joined. A short text field from the 1,000-record file and a numeric field from the 10,000-record file were selected (using the 1,000-record file indexes). The short text field was grouped and sorted in ascending order, the numeric field was subtotaled for each group, and the results output to a null printer. Test times from the last keystroke on the command sequence until return of program control were recorded and averaged.*

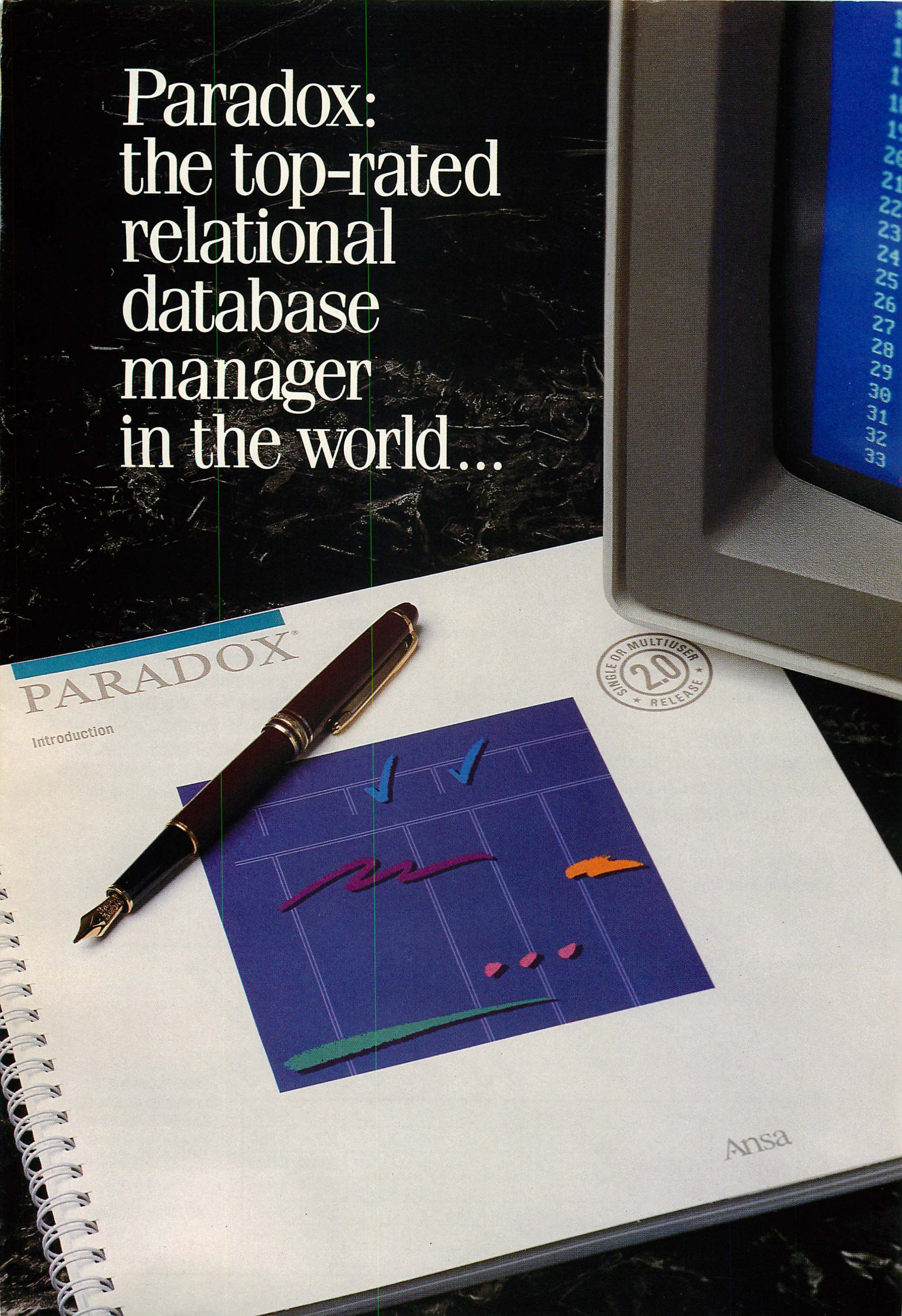
Overall Versatility and Single-Record Search criteria for R:BASE System V were incorrectly reported in a previous version of this advertisement. The correct figures are 8.6 and 1.2, respectively. R:BASE System V ratings for Overall Power and Overall Performance were 6.4 and 4.2, respectively, and its Overall Evaluation was 6.4.

**Reprinted with permission by Software Digest from its July 1987 report covering 12 relational database programs.*

***Rebate request must be received by Borland no later than February 15, 1988. Mail to: Paradox Rebate Department, Borland International, 4585 Scotts Valley Drive, Scotts Valley, CA 95066*



BI-1155B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the top-rated
relational
database
manager
in the world…
PARADOX®
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SINGLE OR MULTIUSER
2.0
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Ansa

DECEMBER 1987

# PC TECH JOURNAL

FOR SYSTEMS DEVELOPERS AND INTEGRATORS



**COVER SUITE: SPEAKING SQL**

**For the distributed database to succeed on PCs, data managers need a common language to speak to each other. While SQL may not be the perfect candidate for standardization, it already exists. We examine its suitability and look at two products that use it.**

**Cover illustration • Andy Levine**



**SAILING THROUGH DATA MANAGEMENT**

Navigating the deep, unsettled sea of information about relational data management required the meticulous research skills and plentiful patience of technical editor Maxine Fontana, our data management specialist. Working with our expert authors and associate editor Jordene Zeimetz, Fontana waded through tomes of material on the subject to compile a cover suite that conveys to our readers a clear understanding of relational databases and SQL. She realizes, of course, this is not the be-all and end-all of data management. SQL will evolve; data management products will improve. This is a topic of growing importance in the PC world, and one that Fontana will continue to chart.

# TECH PC JOURNAL

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**Computer Press Association**

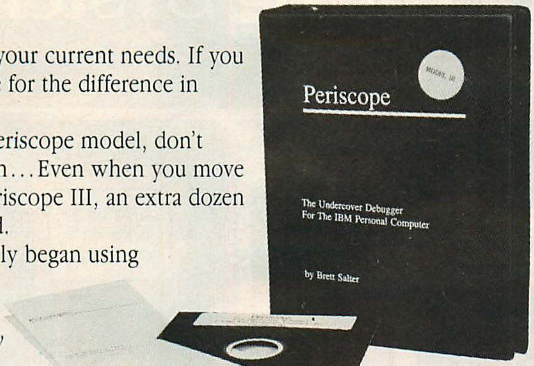
# PERISCOPE™ POWER

## ...Keeps you going full steam ahead when other debuggers let you down! With four models to pick from, you'll find a Periscope that has just the power you need.

Start with the model that fits your current needs. If you need more horsepower, upgrade for the difference in price plus $10!

When you move to another Periscope model, don't worry about having a lot to learn... Even when you move to the most powerful model, Periscope III, an extra dozen commands are all that's involved.

A Periscope I user who recently began using Periscope III writes, *"I like the fact that within the first half hour of use I was debugging my program instead of learning to use the debugger."*

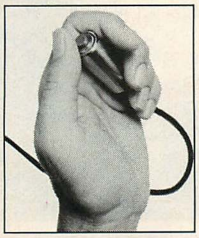



Periscope software & 200+ page manual

■ ***Periscope's software is solid, comprehensive, and flexible.*** It helps you debug just about any kind of program you can write... thoroughly and efficiently.

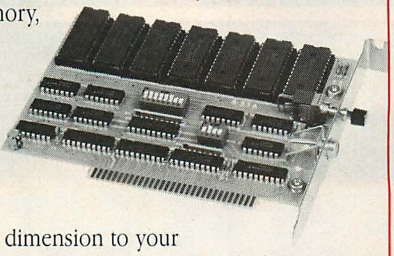
Periscope's the answer for debugging device-drivers, memory-resident, non-DOS, and interrupt-driven programs. Periscope works with any language, and provides source and/or symbol support for programs written in high-level languages and assembler.

■ ***Periscope's hardware adds the power to solve the really tough debugging problems.*** The break-out switch lets you break into the system any time. You can track down a bug instantly, or just check what's going on, without having to reboot or power down and back up. That's really useful when your system hangs! The switch is included with Periscope I, Periscope II, and Periscope III.



Periscope Break-Out Switch

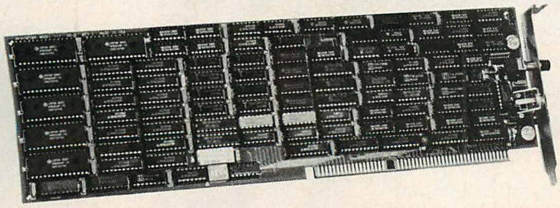
Periscope I has a board with 56K of write-protected RAM. The Periscope software resides in this memory, safe from run-away programs. DOS memory, where debugger software would normally reside, is thus freed up for your program.



Periscope I Board

Periscope III has a board with 64K of write-protected RAM, which performs the same function as the Periscope I protected memory. AND...

The Periscope III board adds another powerful dimension to your debugging. Its hardware breakpoints and real-time trace buffer let you track down bugs that a software-oriented debugger would take too long to find, or can't find at all!



Periscope III Board

## What Periscope Users Like Best:

"I like the clean, solid design and the crash recovery."

**Periscope I user**

"I like the ability to break out of (a) locked up system!"

**Periscope II user**

"I am very impressed with Periscope II-X ... it has become my 'heavy duty' debugger of choice, especially if I need to work on a memory resident utility or a device driver."

**Periscope II-X user**

"... Periscope III is the perfect answer to the debugging needs of anyone involved in real-time programming for the PC ... The real time trace feature has saved me many hours of heartache already."

**Periscope III user**

- **Periscope I** includes a half-length board with 56K of write-protected RAM; break-out switch; software and manual for $345.
- **Periscope II** includes break-out switch; software and manual for $175.
- **Periscope II-X** includes software and manual (no hardware) for $145.
- **Periscope III** includes a full-length board with 64K of write-protected RAM, hardware breakpoints and real-time trace buffer; break-out switch; software and manual. Periscope III for machines running up to 8 MHz is $995; for machines running up to 10 MHz, $1095.

**REQUIREMENTS:** IBM PC, XT, AT, or close compatible (Periscope III requires hardware as well as software compatibility); DOS 2.0 or later; 64K available memory; one disk drive; an 80-column monitor.

Call us with your questions. We'll be happy to send you free information or help you decide on the model that best fits your needs.

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Call Today and Receive a FREE Poster of over 600 Concurrent DOS Applications

# Powerful Multiuser Multitasking Concurrent™ DOS 386 Operating System


## MAXIMUM PERFORMANCE . . .

### Unleash The Power Of The 386!

Concurrent DOS uses the potential of the 386, offering DOS compatibility, combined with multitasking for single-user, and multiuser environments. Up to ten users can share the resources of a single system through simple, easy-to-connect, serial terminals as configured . More users can be added by purchase of a Concurrent DOS System Builder's Kit. Multiuser, Multitasking Applications can be designed using the Concurrent DOS Programmer's Toolkit.

## MAXIMUM COMPATIBILITY . . .

### Runs Concurrent DOS Multitasking Applications And All The Popular PC DOS Applications.

The applications running on your current system (Lotus® 1-2-3®, dBase®III, WordPerfect® and many more) are still useable and don't have to be replaced with "work-alikes" or "compatibles". Concurrent DOS 386 contains windowing capabilities allowing up to four of these applications to run from the primary system console. Concurrent DOS will also allow popular DOS applications to be run from serial terminals.

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DIGITAL RESEARCH

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VERSION 4.10
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Ser. No: OCT '82
Btrieve
Version: IBM PC NETWORK
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Ser. No: MASTER
Btrieve
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Ser. No: (BETA VERSION)
Btrieve
Version: SHAREnet
Ser. No: NOV '83
Btrieve
Version: 4.10 (BETA)
Ser. No: IBM PC NETWORK
Btrieve
Version: PC NET
Ser. No: (BETA VERSION)
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SYSTEMS PERSPECTIVE

JAnderson

# Guarding Your Data

*Can a PC-based data manager provide the control and security that the mainframe world takes for granted?*

Data are assets as critical to a corporation as its employees or capital equipment. If a corporation's data are lost, its ability to conduct business is seriously impaired. Like any other asset, data must be managed and protected.

In order for a PC to host a production database application, it must prove itself a worthy caretaker of the data. Normally this means applying both *programmatic* and *physical* controls. Among the programmatic controls necessary to ensure the integrity and security of corporate data is *transaction processing;* it ensures that a set of operations on the data will be applied either completely or not at all.

*Journaling* is another programmatic control that builds a trail of all data management activity. Should a failure occur, all transactions recorded in the journal are applied to the database, thus recovering the lost data. Finally, *data security* is enforced by controlling access to data through the definition of user views or through access restrictions based on user name or group.

These features, which are so critical to a production application, have been present in mainframe data managers for years. Yet, they have been slow to appear on microcomputers because they affect performance and require additional memory and storage resources. Now, with the power of the 286- and 386-based machines, however, mainframe data managers are beginning to migrate to the PC, bringing with them many of the features necessary to create production applications.

One feature that these data managers do *not* bring to the PC is physical security. An advantage inherent in mainframe data management systems is that the data and the user are physically separate. On the PC, however, the database administrator cannot prevent the user from corrupting the data either intentionally or unintentionally. This is not the fault of the data manager; it is a failing in the operating system. Because neither DOS nor OS/2 enforces sufficient file protection, the user (even outside of the application) can access the files containing the data, write over them, and even delete them.

For this reason, and because the PC user interface is superior to the mainframe's, future applications likely will be designed with the PC acting as an intelligent user-interface engine that communicates data requests to a database engine residing on another platform. However, before this approach can become viable, some enabling technology must be in place—specifically, a multitasking operating system (such as OS/2 or UNIX) and a process-to-process communications protocol (such as IBM's APPC).

Further, the database engine and user interface engine will need to speak a common language. Structured Query Language (SQL) is gaining widespread acceptance as this language. The reason for standardizing on SQL is simply because it's already there. SQL is the most commonly implemented data management language, plus it enjoys the blessings of IBM and E. F. Codd, developer of the relational model of database design. Turning to SQL is easier than teaching the data management world an entirely new language.

In the years since SQL was introduced and the ANSI standard for SQL was proposed, many dialects have arisen. In fact, because the ANSI committee deliberately left the implementation of some features to the user, multiple dialects are not only tolerated but encouraged, thus complicating what was intended to simplify.

With the industry's cooperation in defining this "standard," SQL is expected to shine as a means for communicating between heterogeneous databases. As Rick Richardson of Arthur Young said in February at the 1987 PC Forum, in Phoenix, "We have invested 4½ times more money in data than we have in hardware and software put together. We're tired of people bringing out brand-new products that don't work with old data." With SQL, new applications can be built that access existing databases transparently.

In the meantime, these powerful data managers that have migrated from mainframes offer advantages for applications where strict security is not required. With a data manager that runs on a variety of architectures, an appli-

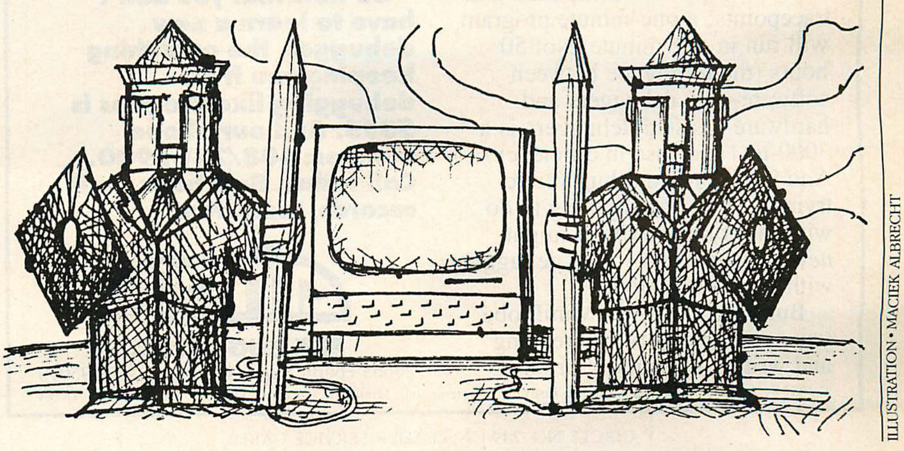

ILLUSTRATION • MACIEK ALBRECHT

cation can be ported easily throughout the corporation. Using the same data manager for all applications in a corporation, whether PC- or mainframe-based, reduces the costs of training the developer and the end user. Furthermore, with a data manager that runs on a variety of machines, developers can deliver vertical applications on whatever architecture the client owns and can create applications that share work-group data on a minicomputer or through a local area network (LAN).

Small business application requirements that can be met on a PC also benefit from the migrated data managers. Small businesses frequently grow into larger businesses, and small applications grow into larger ones. Once the PC is outgrown, an application can be ported onto a larger machine without extensive reprogramming.

Finally, the PC can serve as a development workstation, thereby offloading development from the mainframe. Production applications can be prototyped, developed, and tested on a PC before use on the mainframe.

In this issue, in a cover suite compiled by our data management specialist, Maxine Fontana, we first define SQL and examine its suitability as a means for communicating among heterogeneous relational databases. Next, two SQL mainframe data managers that have migrated to the PC are submitted to the scrutiny of our standard data manager evaluation criteria: INGRES from Relational Technology, Inc. (RTI) and ORACLE from Oracle Corporation.

In porting these data managers to the PC, each company took a different approach. To live within the 640KB memory limitation of DOS, RTI chose to implement a subset of features found in INGRES on larger systems. Oracle Corporation overcame the limitation by implementing its own extended memory manager so that ORACLE runs in protected mode on a 286 machine under DOS. This means that a 286 machine with extended memory at minimum is needed to run ORACLE, but Oracle was able to implement all features found on its other systems.

Both RTI and Oracle are releasing LAN database servers running under a version of UNIX that will accept SQL queries from the PC-based nodes on the network, thus heralding true distributed applications and physically separating user from data. This is a big step forward from the current state of the art in LAN data managers in which a database on the LAN server is shared by multiple copies of the data manager running on the network nodes.

With the right combination of data managers, multiuser operating system, and network protocol, PCs definitely have a place in the world of the distributed database.

### DEBATES AT THE FORUM

Also in this issue is a special report by executive editor Susan Holly on the first *PC Tech Journal* Systems Forum. In an intense 2½ days in San Diego this past September, we debated the issues facing systems professionals: is OS/2 worth waiting for, is the PS/2 worth buying, which emerging LAN standards will be useful, where is the future of data management heading?

The Systems Forum proved to be an invaluable opportunity for many of our readers, who are among the leading systems developers and integrators, to update vendors on their concerns. We hope to see even more of you at our 1988 Systems Forum.

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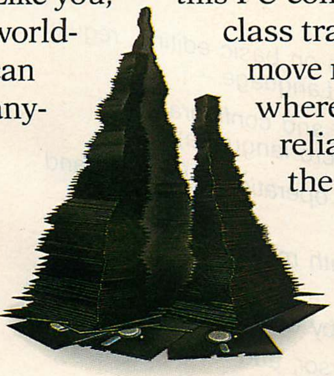

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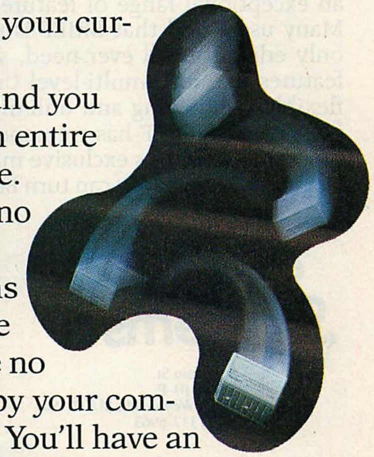

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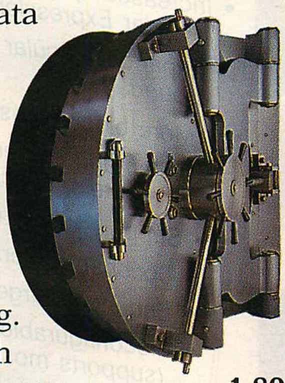

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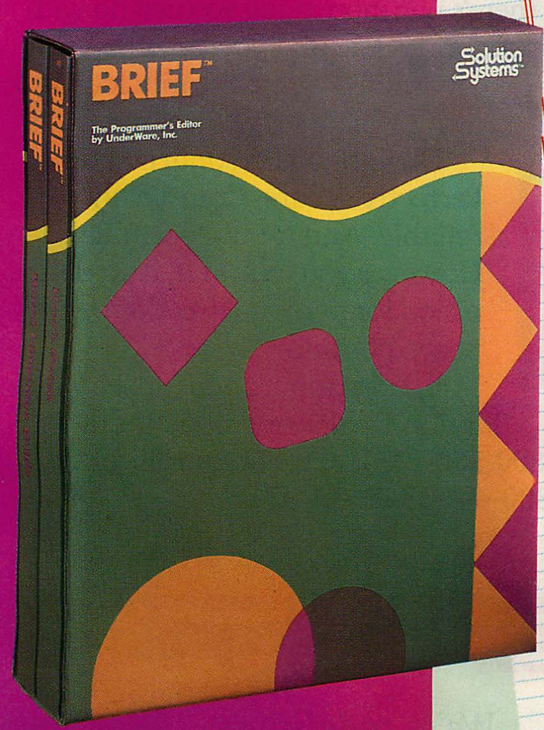


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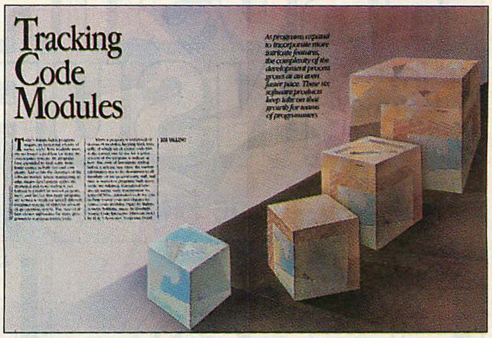
# LETTERS


Tracking Code Modules

**A CASE FOR SCMS**

Having just read your review of our product, the Software Revision Management System (SRMS), in the September issue ("Tracking Code Modules, Jim Vallino, p. 50), we were pleased with the article's accuracy and objectivity. However, Mr. Vallino did incorrectly report two items with respect to SRMS.

First, with respect to table 1, Mr. Vallino notes that SRMS supports only one level of branching. This is not the case; the number of branch levels is unlimited. The user is restricted only in the sense that the number of trunk and branch deltas in a library module not exceed the 500 revisions allowed.

Mr. Vallino also states, "When SRMSINFO MODULE.C was accidentally run to display information about this single module, the program generated the status report using MODULE.C as an output file. This destroyed the working copy of this source file in the process. All modifications performed since it was checked out were lost."

When we tried to duplicate the problem with SRMSINFO, we received the following error message:

**Outputfile <MODULE.C > Exists . . .**
**Replace (DESTROY) It? (Y/N)?**

As in this case, SRMS is generally very cautious about overwriting output files without some input from the user.

Finally, in the sidebar "Automatic Program Building" (p. 59), Mr. Vallino notes that "Both Polytron's and Seidl's SCMSs have separate MAKE type products . . ." Quilt also markets a MAKE utility (QMAKE) that is fully integrated with our SRMS product, giving the end user complete control of system generation capabilities.

Thank you again for bringing the important subject of configuration management to your readers.

*Thomas Igielski*
*Quilt Computing*
*Woodbury, MN*

Thank you for reviewing the Seidl Version Manager (SVM) in "Tracking Code Modules." Overall, the review by Jim Vallino was quite fair and accurate. There were a few minor inaccuracies that I would like to point out.

In the table of features (p. 61), SVM version 1.05 is listed as having only eight levels of branching when it actually has unlimited branching. Also, it is listed as having merge capabilities when, in fact, version 1.05 does not.

On October 1, 1987, we released SVM version 2.0, which addresses every shortcoming the reviewer found with version 1.05 and also contains features and utility programs that were not considered in the review.

*F. Andy Seidl, vice president*
*Seidl Computer Engineering*
*Ann Arbor, MI*

*Regarding the comments by Mr. Igielski and Mr. Seidl about unlimited branching capabilities, I stand by the information presented in table 1 (p. 61). There may be a misunderstanding concerning what I call a* branch level. *I have defined a level of branching as a parallel development path that splits from a particular revision of the source file. A source code management system (SCMS) indicates the branch by appending a branch major/minor revision number to the major/minor revision number of the base, such as branch revisions 1.2.1.1, 1.2.1.2, and 1.2.2.1 developing from revision 1.2. To support more than one level of branching, the SCMS must allow for another development path to be created parallel to the branch development line. This "branch from a branch" would have a revision number such as 1.2.2.1.1.1.*

*The version of Quilt Computing's SRMS that was reviewed, version 3.0, supports revision numbers with up to four components in the form R.L.B.S. (standing for Release, Level, Branch, and Sequence, respectively). Release and Level can be associated with the trunk major and minor revision numbers, while Branch and Sequence are the branch major and minor numbers for the first level of branches. The branch level limit of one specified for SRMS implies neither a limit on the numeric values for any of the four parts of SRMS's revision number nor a limit on the number of different branches that can be created from the main development path. It does mean, though, that you cannot create a "branch from a branch" in a way that will maintain consistent revision numbering.*

*In a similar fashion, revisions are numbered with up to eight components for the Seidl Computer Engineering's SVM 1.05. These components are treated individually (that is, not as major/minor pairs), so it is possible to maintain consistent revision numbering with up to seven levels of branching, setting aside one component to represent the main development trunk.*

*I went back and tested the problem reported with SRMS's SRMSINFO program. It is a problem clearly evident in the version provided for review. When a file is taken out for edit to create a new revision, such as MODULE.C, this file is overwritten if the command SRMSINFO MODULE.C is run when in the same directory. No warning message is generated. A search of the SRMSINFO.COM file did not reveal any printable strings that could be used to generate the message specified in Mr. Igielski's letter. Perhaps there is a newer version of SRMSINFO that is more cautious about overwriting output files.*

*I apologize for not noting Quilt's QMAKE utility in the sidebar. It was omitted because the SRMS documentation reviewed made no references to it. I suggest that Quilt add this information to the section titled "Project Management with SRMS" when the documentation is next released.*

*—Jim Vallino*

## LETTERS

### A VIEW FROM AFAR

As an avid reader of your excellent publication, I have been following both your editorial views and the views expressed by your readers on the IBM Personal System/2 models (see the August 1987 issue). After reading Mr. Fuchs' letter "Power Shaft/2" in your August issue (p. 15), I decided to put pen to paper to answer his points from a more positive perspective:

- Micro Channel. So what if similar architecture has manifested itself in mini- and mainframes before, it is a step forward for microcomputers.
- I see no evidence that IBM has locked anyone into a single vendor. All of the major third-party vendors have either shipped or announced products to work with MCA (DCA, AST, CORE) and with the Micro Channel's bus arbitration, watch this space for add-ons never dreamed of.
- I also will add that Apple, considered to be one of the major innovators of the industry, saw fit to equip its Mac II with NuBus, a very similar system.
- You chose XENIX—this is your choice, not mine nor millions of others. Believe it or not, not everyone thinks UNIX is what computing was invented for—ask two million plus Lotus 1-2-3 users, for example. Already the choice of operating systems is expanding. Choices either include or will include DOS 3.3, DOS 3.3 with Microsoft Windows, DOS 3.3 with DRI's GEM, DOS 3.3 with Quarterdeck's DESQview, AIX, UNIX, PICK, and many more. When will some people learn that for the vast majority of users, computers are a means to an end not an end in themselves.
- Video Graphics Array. They could have gone further, but you have got to allow all of those people whose livelihood depends on enhancing IBM's offering an in to the market.
- ESDI? My understanding is that Models 60-071, 80-071, 80-111 all have an ESDI, as for the lower models, look for third-party solutions.
- Diskettes are important to the vast majority of users, my data is much safer when I carry it around the country on 3.5-inch media.
- IBM, in keeping the PC's architecture open, created a platform for microcomputing to move forward for the good of most users, and by retaining its openness I believe history will repeat itself. As for science and technology, I am sure that from IBM, whose R & D budget must be in the billions of dollars, does very nicely.

In my opinion, IBM has produced a range of products that are both well-designed and engineered. Having had the privilege to visit both IBM's Boca Raton, Florida and Greenock, Scotland facilities to see both development and manufacture, I can attest to the level of investment IBM has gone to make these excellent products.

IBM has been very open about the reasons behind PS/2 and has retained an open system (contrary to market expectation before April 2, 1987) and with the erosion of their market share by PC clones, this stance can only be applauded. I thought that knocking success was a British problem, it is obviously more widespread than I thought.

In the end, the market will decide. I, like IBM, believe that the corporate market at least will go PS/2 and Micro Channel Architecture and probably OS/2. Whether or not IBM supplies the lion's share depends on how quickly the others can catch up.

*Colin Budgen*
*P & P Micro Distributors, PLC*
*London, England*

### A VOTE FOR MAC

I have always looked to *PC Tech Journal* for the latest advancements in computer technology, software, and programming tools. My faith in your progressive reporting is reinforced by your consideration of the Macintosh family (see "Mac II Attack," Directions, Will Fastie, June 1987, p. 9).

As you pointed out, Intel 86 series users and programmers have a vested interest in the IBM standard. We have made a considerable investment in both equipment and knowledge.

In January I was introduced to a Macintosh for preparation of some simple overheads. I had been impressed with the flexibility and quality of other presentations prepared on the Mac. In March, I purchased a new Macintosh SE. By May, my only use for an IBM was to update reports that had not yet been transferred to the Mac. If Javelin would introduce a Mac version of their software, my conversion would be complete. (If software companies don't comply, they too will be left behind.)

I work for a large pharmaceutical firm that is considering the Macintosh as a standard workstation for the hundreds of financial analysts currently using IBM PCs. Apple is certainly making a move into corporate America.

Yes, I would like you to follow the Apple Macintosh with the same zeal that you have followed the IBM PC for the past four years. Congratulations on your open-minded search of computer advancements.

*Rob Bush*
*Indianapolis, IN*

### CALL FOR TECH NOTES

As befits a publication with a highly technical readership, *PC Tech Journal* has, since its inception, published a column of short solutions to technical problems under the title Tech Notebook. We have published some great ones, and we continue to improve our service in this area. Along with the other changes planned, we will be expanding this department under the new title, Tech Notes, which will be brought together by technical editor Ted Mirecki. The new format will be more flexible, in part because each item will not be constrained to the one-page format.

Readers are invited to submit items that are appropriate to the technical expertise of our audience. Illustrations by code fragments or *short* files of both text and programs are welcome. Please send hard copy and disk files of both text and programs to the attention of Ted Mirecki, *PC Tech Journal*, Suite 800, 10480 Little Patuxent Parkway, Columbia, MD 21044, identifying them as intended for the Tech Notes department. Text files may be in WordPerfect, Word, WordStar, or plain ASCII format; source code must be plain ASCII ready for input to a compiler or assembler. Upon acceptance, payment will be made depending on length and content.

*—JA*

### COMMENTS WELCOME

All letters to the editor should be directed to Editor, *PC Tech Journal*, Suite 800, 10480 Little Patuxent Parkway, Columbia, MD 21044. Correspondence also can be submitted over MCI Mail to PCTECH.

Although *PC Tech Journal* cannot publish all letters received, every effort is made to answer as many as possible. Please keep letters brief and to the point, and include name, mailing address, and telephone number; when a letter is lengthy, a diskette is appreciated.

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## borland products

| | List | Ours |
|---|---|---|
| EUREKA *Equation Solver* | 167 | 105 |
| Reflex: The Analyst | 150 | 99 |
| Sidekick | 85 | 57 |
| Superkey | 100 | 64 |
| Turbo Basic Compiler | 100 | 64 |
| Turbo Basic Database Toolbox | 100 | 64 |
| Turbo Basic Editor Toolbox | 100 | 64 |
| Turbo Basic Telecom Toolbox | 100 | 64 |
| Turbo C Compiler *(Call for support products)* | 100 | 64 |
| Turbo Lightning and Word Wizard | 150 | 94 |
| Turbo Lightning | 100 | 64 |
| Turbo Lightning Word Wizard | 70 | 47 |
| Turbo Pascal and Tutor *New Version* | CALL | CALL |
| Turbo Pascal *New Version* | 100 | 64 |
| Turbo Pascal Tutor | 70 | 41 |
| Turbo Pascal Database Toolbox | 100 | 64 |
| Turbo Pascal Developer's Toolkit | 395 | 289 |
| Turbo Pascal Editor Toolbox | 100 | 64 |
| Turbo Pascal Gameworks Toolbox | 100 | 64 |
| Turbo Pascal Graphix Toolbox | 100 | 64 |
| Turbo Pascal Numerical Methods Toolbox | 100 | 64 |
| Turbo Prolog Compiler | 100 | 64 |
| Turbo Prolog Toolbox | 100 | 64 |

## c language

| | List | Ours |
|---|---|---|
| C-terp *by Gimpel, Specify compiler* | 298 | 219 |
| C Trainer *with Book by Catalytix* | 122 | 87 |
| DeSmet C *w/Debugger & Large case* | 209 | 184 |
| DeSmet C *w/Debugger only* | 159 | 138 |
| Eco-C88 Modeling Compiler *by Ecosoft* *New* | 100 | 79 |
| Instant C *by Rational Systems* | 495 | 369 |
| Lattice C Compiler *vers. 3.2 from Lattice* | 500 | 265 |
| Mark Williams Let's C *with FREE csd* | 75 | 54 |
| Microsoft C Compiler 5.0 w/CodeView *SALE* | 450 | 259 |
| Microsoft QuickC Compiler *SALE* | 99 | 59 |
| Optimum-C *by Datalight* | 139 | 95 |
| Turbo C Compiler *by Borland* | 100 | 64 |
| Uniware 68000/10/20 Cross Compiler *by SDS* | 995 | 829 |

## c utilities

| | List | Ours |
|---|---|---|
| Blackstar C Library *by Sterling Castle* | 125 | 98 |
| C++ *by Guidelines w/version 1.1 kernel* | 195 | 172 |
| c-tree & r-tree Combo *by FairCom* | 650 | 519 |
| c-tree *ISAM File Manager* | 395 | 315 |
| r-tree *Report Generator* | 295 | 239 |
| Csharp Realtime Toolkit *by Systems Guild* | 600 | 489 |
| Curses Window Dev Pkg *by Aspen Scientific* | 119 | 105 |
| *with Source Code* | 289 | 249 |
| JBx *dBASE to C Translator by Desktop AI* | 350 | 299 |
| *with Source Code* | 550 | 419 |
| Flash-up *by Software Bottling* | 90 | 78 |
| GraphiC *Color version by Sci Endeavors* | 350 | 274 |
| HALO *Graphics by Media Cybernetics* | 300 | 205 |
| HALO Development Pkg *for Microsoft* | 595 | 389 |
| The HAMMER *by OES Systems* | 195 | 129 |
| PANEL/TC *for Turbo C by Roundhill* | 129 | 95 |
| PANEL Plus *by Roundhill* | 495 | 395 |
| PC Lint *by Gimpel Software* | 139 | 99 |
| RTC PLUS *Fortran to C by Cobalt Blue* | 450 | 399 |
| Sapiens V8 *Virtual Memory Manager* | 300 | 265 |
| Scientific Subroutine Library *by Wiley* | 175 | 135 |
| TE Text Editor *source by Sub Systems* | 95 | 85 |
| Vitamin C *by Creative Programming* | 225 | 149 |
| VC Screen *Forms Designer* | 100 | 79 |
| Zview *by Data Mgmt Consultants* | 245 | 139 |

## cobol language

| | List | Ours |
|---|---|---|
| COBOLspII *by Flexus* | 395 | 329 |
| FPLIB *for Realia COBOL by BCSoft* | 149 | 129 |
| Micro Focus COBOL *See Micro Focus Section* | | |
| Microsoft COBOL *See Microsoft Section* | | |
| PCDT *by Pro-Code* | 995 | 895 |
| Realia COBOL with RealMENU | 1145 | 899 |
| Realia COBOL | 995 | 783 |
| RealCICS | 995 | 783 |
| RM/COBOL *by Ryan-McFarland* | 950 | 639 |
| RM/COBOL 85 *by Ryan-McFarland* | 1250 | 895 |
| RM/NET+5 *by Ryan-McFarland* | 300 | 259 |
| RM/Screens | 395 | 334 |
| SCREENIO *by Norcom* | 400 | 379 |
| screenplay *for COBOL by Flexus* | 175 | 129 |

## css products

| | List | Ours |
|---|---|---|
| Combo Package *by Custom Software Systems* | 199 | 175 |
| PC/TOOLS *UNIX-like Utilities* | 49 | 45 |
| PC/VI *vi Editor* | 149 | 99 |

## database management

| | List | Ours |
|---|---|---|
| Advanced DBMaster *by Macon Software* *New* | 510 | 419 |
| dBASE III Plus *by Ashton-Tate* *New* | 695 | 389 |
| dBIII Compiler *by WordTech Systems* *New* | CALL | CALL |
| dbSQL *by WordTech Systems* *New* | CALL | CALL |
| dbXL *by WordTech Systems* *New* | 169 | 109 |
| dFLOW *by Wallsoft* *New* | 149 | 119 |
| The Documenter *by Wallsoft* *New* | 295 | 239 |
| Genifer *by Bytel* *New* | 395 | 279 |
| Paradox 1.1 *by Ansa/Borland* *New* | 495 | 359 |
| Paradox 2.0 *by Ansa/Borland* *New* | 725 | 525 |
| Paradox Network Pack *by Ansa/Borland* *New* | 995 | 725 |
| Q&A *by Symantec* *New* | 349 | 219 |
| Quickcode PLUS *by Fox & Geller* *New* | 295 | 179 |
| Quickindex *by Fox & Geller* *New* | 149 | 95 |
| Quickreport *by Fox & Geller* *New* | 295 | 179 |
| QuickSilver *by WordTech Systems* *New* | 599 | 349 |
| R:Base 5000 *by Microrim* *New* | 495 | CALL |
| R:Base System V *by Microrim* *New* | 700 | CALL |
| \ rdb *by Robinson-Shafer-Wright* *New* | 139 | 119 |
| Tom Rettig's Library *by Tom Rettig & Assoc* *New* | 100 | 79 |
| UI Programmer *by Wallsoft* *New* | 295 | 239 |
| VP INFO *by Paperback Software* *New* | 100 | 63 |

## debuggers & profilers

| | List | Ours |
|---|---|---|
| 386 DEBUG *Cross Debugger by Phar Lap* | 195 | 129 |
| Advanced Trace-86 *by Morgan Computing* | 175 | 115 |
| Codesmith-86 *by Visual Age* | 145 | 98 |
| DSD87 *by Soft Advances* | 125 | 79 |
| MiniProbe *by Atron* | 395 | 369 |
| Periscope I *with Board by Periscope* | 345 | 275 |
| Periscope I *with NMI Breakout Switch* | 175 | 139 |
| Periscope II-X *Software only* | 145 | 105 |
| Periscope III *8 MHz version* | 995 | 795 |
| Periscope III *10 MHz version* | 1095 | 875 |
| The PROFILER *with Source Code by DWB* | 125 | 89 |
| TURBOsmith *Source debugger for Turbo Pascal* | 99 | 89 |
| The WATCHER *Profiler by Stony Brook* | 60 | 51 |

## disk utilities

| | List | Ours |
|---|---|---|
| Back-It *by Gazelle Systems* *New Version* | 130 | 115 |
| Disk Optimizer *by Softlogic Systems* | 60 | 55 |
| Disk Technician *by Prime Solutions* | 100 | 89 |
| FASTBACK *by 5th Generation Systems* | 179 | 129 |
| Take Two Manager *United Software Security* *New* | 139 | 119 |
| Vcache *by Golden Bow Systems* | 50 | 47 |
| Vopt *by Golden Bow Systems* | 50 | 47 |
| Vfeature *by Golden Bow Systems* | 80 | 74 |
| Vfeature Deluxe *by Golden Bow Systems* | 120 | 111 |
| XenoCopy-PC *by XenoSoft* | 80 | 69 |

## dos utilities

| | List | Ours |
|---|---|---|
| Advanced Norton Utilities | 150 | 89 |
| Command Plus *by ESP Software* | 80 | 69 |
| Desqview *from Quarterdeck* | 130 | 115 |
| FANSI-CONSOLE *by Hersey Micro* | 75 | 62 |
| Mace Utilities *Paul Mace Software* | 99 | 89 |
| MicroHelp Utility *by MicroHelp* | 59 | 49 |
| Norton Commander *by Peter Norton* | 75 | 55 |
| Norton Utilities *by Peter Norton* | 100 | 59 |
| OPAL *Shell Language by Software Factory* | 99 | 89 |
| Q-DOS II *by Gazelle Systems* | 70 | 59 |
| Taskview *by Sunny Hill Software* | 80 | 55 |

## essential products

| | List | Ours |
|---|---|---|
| Breakout Debugger Only *Any language* | 125 | 89 |
| C Utility Library | 185 | 119 |
| Essential Communications | 185 | 125 |
| Essential Communications *with Break Out* | 250 | 189 |
| Essential Graphics | 250 | 183 |
| /*resident_C*/ *New* | 99 | 85 |
| *with Source Code* *New* | 198 | 169 |
| ScreenStar *New* | 99 | 85 |
| *with Library Source Code* *New* | 198 | 169 |

## forth language

| | List | Ours |
|---|---|---|
| CFORTH *Native Code Compiler by LMI* | 300 | 229 |
| FORTH/83 Metacompiler *Specify Target* | 750 | 599 |
| PC/FORTH *by Laboratory Microsystems* | 150 | 109 |
| PC/FORTH+ *by Laboratory Microsystems* | 250 | 199 |
| Programmer's Package #1 *by LMI* | 250 | 199 |
| Programmer's Package #2 *by LMI* | 350 | 279 |
| Programmer's Package #3 *by LMI* | 500 | 399 |
| UR/FORTH *Also Available for OS/2 by LMI* | 350 | 279 |
| *UR/FORTH Libraries* | 500 | 395 |

## fortran language

| | List | Ours |
|---|---|---|
| 50 MORE: FORTRAN *by Peerless Scientific* | 125 | 95 |
| ACS Time Series *by Alpha Computer Service* | 495 | 389 |
| AUTOMATED PROGRAMMER *by KGK Automated* | 995 | 949 |
| Essential Graphics *by Essential Software* | 250 | 183 |
| Forlib-Plus *by Alpha Computer Service* | 70 | 44 |
| FORTRAN Addendum *by Impulse Engr* | 95 | 85 |
| FORTRAN Addenda *by Impulse Engr* | 165 | 138 |
| HALO *Graphics by Media Cybernetics* | 300 | 205 |
| I/O PRO w/No Limit Library *by MEF* | 250 | 219 |
| Microcompatibles Combo Package | 240 | 215 |
| Grafmatic | 135 | 117 |
| Plotmatic | 135 | 117 |
| Microsoft FORTRAN *w/CodeView* *SALE* | 450 | 259 |
| No Limit Library *by MEF Environmental* | 129 | 109 |
| Numerical Analyst *by MAGUS* | 295 | 249 |
| PANEL *by Roundhill Computer Systems* | 295 | 199 |
| RM/FORTRAN *by Ryan-McFarland* | 599 | 399 |
| RTC PLUS *Fortran to C by Cobalt Blue* | 450 | 399 |
| Scientific Subroutine Library *by Wiley* | 175 | 135 |
| Statistician *by Alpha Computer Service* | 295 | 235 |
| STATLIB.GL: *by Wiley* | 295 | 239 |
| STATLIB.TSF: *by Wiley* | 295 | 239 |
| Strings & Things *by Alpha Computer Service* | 70 | 45 |

## greenleaf products

| | List | Ours |
|---|---|---|
| Greenleaf C Sampler *for QuickC & Turbo C* | 95 | 69 |
| Greenleaf Comm Library | 185 | 125 |
| Greenleaf Data Windows Library | 225 | 155 |
| *with Source Code* | 395 | 249 |
| Greenleaf Functions | 185 | 125 |

## help utilities

| | List | Ours |
|---|---|---|
| HELP/Control *by MDS* | 125 | 99 |
| On-line Help *from Opt-Tech* | 149 | 99 |
| SoftScreen/HELP *by Dialectic Systems* | 195 | 149 |

## lattice products

| | List | Ours |
|---|---|---|
| Lattice C Compiler *ver 3.2 from Lattice* | 500 | 265 |
| *with Library Source Code* | 900 | 495 |
| C Cross Reference Generator | 50 | 37 |
| *with Source Code* | 200 | 139 |
| C-Food Smorgasbord *Function Library* | 150 | 95 |
| *with Source Code* | 300 | 179 |
| C-Sprite *Source Level Debugger* *Special Offer* | 175 | CALL |
| Curses *Screen Manager* | 125 | 85 |
| *with Source Code* | 250 | 169 |
| dBC III | 250 | 169 |
| *with Source Code* | 500 | 356 |
| dBC III Plus | 750 | 594 |
| *with Source Code* | 1500 | 1184 |
| LMK *Make Facility* | 195 | 138 |
| RPG II Combo *All three items below* | 1100 | 875 |
| RPG II *Compiler No Royalties* | 750 | 625 |
| SEU *Source Entry Utility* | 250 | 199 |
| Sort/Merge | 250 | 199 |
| Screen Design Aid Utility *for RPG II* | 350 | 309 |
| SecretDisk II *Encryption Utility* | 120 | 88 |
| SideTalk *Resident Communications* | 120 | 88 |
| SSP/PC *Scientific Subroutine Library* | 350 | 269 |
| Text Management Utilities | 120 | 88 |

## metagraphics products

| | List | Ours |
|---|---|---|
| LightWINDOW/C *for Datalight C* | 95 | 79 |
| MetaWINDOW *No Royalties* | 195 | 159 |
| MetaWINDOW/PLUS | 275 | 229 |
| TurboWINDOW/C *for Turbo C* | 95 | 79 |
| TurboWINDOW/Pascal *for Turbo Pascal* | 95 | 79 |

## micro focus products

| | List | Ours |
|---|---|---|
| Micro Focus COBOL/2 | 900 | 729 |
| Micro Focus Level II COBOL *w/Animator* | 495 | 395 |
| Level II COBOL | 349 | 279 |
| Level II Animator | 195 | 155 |
| Micro Focus Level II COBOL/ET for UNIX | CALL | CALL |

| | | |
|---|---|---|
| Micro Focus PC-CICS ........ *New* | 1495 | 1189 |
| *with Micro/SPF* ........ *New* | 1595 | 1269 |
| Micro Focus Personal COBOL ........ | 149 | 119 |
| Micro Focus Professional COBOL ........ | 2000 | 1595 |
| Micro Focus VS COBOL/XENIX ........ | 1495 | 1195 |
| Micro Focus Support Products: | | |
| COBOL/IQ *Ad hoc Report Writer* ........ | 495 | 395 |
| COBOL/IQ *for DOS 3.X Networks* ........ | 995 | 795 |
| FORMS-2 ........ | 295 | 235 |
| SOURCEWRITER ........ | 995 | 795 |

## microport products

| | | |
|---|---|---|
| 386 Unlimited License Kit ........ | 249 | 209 |
| AT Unlimited License Kit ........ | 249 | 209 |
| DOSMerge286 *Run DOS and UNIX together* ........ | 149 | 129 |
| DOSMerge386 *Run DOS and UNIX together* ........ | CALL | CALL |
| System V/386 Combination ........ | 799 | 669 |
| 386 Runtime System ........ | 199 | 169 |
| 386 Software Development System ........ | 499 | 429 |
| Text Preparation System ........ | 199 | 169 |
| System V/AT Combination ........ | 549 | 465 |
| AT Runtime System ........ | 199 | 169 |
| AT Software Development System ........ | 249 | 209 |
| Text Preparation System ........ | 199 | 169 |

## microsoft products

| | | |
|---|---|---|
| Microsoft BASIC Compiler *for XENIX* ........ | 695 | 419 |
| Microsoft BASIC Interpreter *for XENIX* ........ | 350 | 209 |
| Microsoft C Compiler 5.0 *w/CodeView* ........ *SALE* | 450 | 259 |
| Microsoft COBOL Compiler *with COBOL Tools* . *SALE* | 700 | 419 |
| *for XENIX* ........ *SALE* | 995 | 599 |
| Microsoft Excel ........ *New* | 495 | 295 |
| Microsoft FORTRAN *Optimizing Compiler* ... *SALE* | 450 | 259 |
| Microsoft FORTRAN *for XENIX* ........ | 695 | 409 |
| Microsoft Learning DOS ........ | 50 | 36 |
| Microsoft Macro Assembler ........ *SALE* | 150 | 89 |
| Microsoft Mouse *Specify Serial or Bus* ........ | 150 | 99 |
| *with Microsoft Windows* ........ | 200 | 135 |
| *with EasyCAD* ........ | 175 | 114 |
| Microsoft Pascal Compiler ........ *SALE* | 300 | 174 |
| *for XENIX* ........ *SALE* | 695 | 409 |
| Microsoft QuickBASIC 4.0 ........ *SALE* | 99 | 59 |
| Microsoft QuickC ........ *SALE* | 99 | 59 |
| Microsoft Windows ........ | 99 | 63 |
| Microsoft Windows Development Kit ........ | 500 | 299 |
| Microsoft Word ........ | 450 | 269 |
| Microsoft Works ........ *New* | 195 | 119 |

## mks products

| | | |
|---|---|---|
| MKS AWK ........ | 75 | 65 |
| MKS RCS *Revision Control System* ........ *New* | 189 | 155 |
| MKS Toolkit *with MKS VI Editor* ........ | 139 | 109 |
| MKS Trilogy *with AWK, CRYPT & Korn Shell* ... *New* | 119 | 99 |
| MKS VI *Editor by MKS* ........ | 75 | 65 |

## modula-2 language

| | | |
|---|---|---|
| LOGITECH Modula-2 Development System ........ | 249 | 199 |
| Modula-2 Compiler Pack ........ | 99 | 79 |
| Modula-2 Toolkit ........ | 169 | 139 |
| LOGITECH Modula-2 ROM Pkg ........ | 299 | 239 |
| LOGITECH Modula-2 Window Pkg ........ | 49 | 39 |
| Macro2 *Macro preprocessor by PMI* ........ | 89 | 79 |
| ModBase *by PMI* ........ | 89 | 79 |
| Repertoire *by PMI* ........ | 89 | 75 |
| Science & Engrg Tools *by Quinn-Curtis* ........ | 75 | 67 |
| Universal Graphics Library *by Quinn-Curtis* ........ | 130 | 119 |

## mouse products

| | | |
|---|---|---|
| LOGIMOUSE BUS *with PLUS Pkg by LOGITECH* .... | 119 | 98 |
| *with PLUS & PC Paintbrush* ........ | 149 | 119 |
| *with PLUS & CAD Software* ........ | 189 | 153 |
| *with PLUS & CAD & Paint* ........ | 219 | 179 |
| *with PLUS & First Publisher* ........ | CALL | CALL |
| LOGIMOUSE C7 *with PLUS Pkg, Specify Connector* ... | 119 | 98 |
| *with PLUS & PC Paintbrush* ........ | 149 | 119 |
| *with PLUS & CAD Software* ........ | 189 | 153 |
| *with PLUS & CAD & Paint* ........ | 219 | 179 |
| *with PLUS & First Publisher* ........ | CALL | CALL |
| Microsoft Mouse *See Microsoft Section* | | |

## other languages

| | | |
|---|---|---|
| ACTOR *by Whitewater Group* ........ | 495 | 419 |
| CCS MUMPS *All varieties by MGlobal* ........ | CALL | CALL |
| Marshal Pascal *by Marshal Language Systems* ..... | 189 | 155 |
| Pascal-2 *by Oregon Software* ........ | 395 | 325 |
| Personal REXX *by Mansfield Software* ........ | 125 | 99 |
| SNOBOL4+ *by Catspaw* ........ | 95 | 80 |

## other products

| | | |
|---|---|---|
| Carbon Copy Plus *by Meridian Technology* ........ | 195 | 159 |
| Dan Bricklin's Demo Pgm *by Software Garden* ..... | 75 | 57 |
| Dan Bricklin's Demo Tutorial ........ | 50 | 45 |
| Fast Forward *by Mark Williams* ........ | 70 | 59 |
| Instant Replay *by Nostradamus* ........ | 150 | CALL |
| MicroTEX *Typesetting from Addison-Wesley* ........ | 295 | CALL |
| Printer Drivers ........ *New* | CALL | CALL |
| muMATH *by Soft Warehouse* ........ *New* | 300 | 199 |
| Net-Tools *by BCSoft* ........ | 149 | 129 |
| Norton Guides *Specify Language* ........ | 100 | 65 |
| OPT-Tech Sort *by Opt-Tech Data Proc* ........ | 149 | 99 |
| PC/TOOLS *by Custom Software* ........ | 49 | 45 |
| Resident Expert *Specify lang by Santa Rita* .... *New* | 59 | 55 |
| Screen Machine *by MicroHelp* ........ | 79 | 59 |
| SuperSort *by LifeStyle* ........ | 139 | 119 |

## phoenix products

| | | |
|---|---|---|
| Pasm86 *Macro Assembler version 2.0* ........ | 195 | 108 |
| Pdisk *Hard Disk & Backup Utility* ........ | 145 | 99 |
| Pfantasy Pac *Phoenix Combo* ........ | 995 | 595 |
| Pfinish *Execution Profiler* ........ | 395 | 209 |
| Pfix86plus *Symbolic Debugger* ........ | 395 | 209 |
| PforCe *Specify C Compiler* ........ | 395 | 209 |
| PforCe++ *Specify C Compiler and C++* ........ | 395 | 209 |
| Plink86plus *Overlay Linker* ........ | 495 | 275 |
| Pmaker *Make Utility* ........ | 125 | 78 |
| Pmate *Macro Text Editor* ........ | 195 | 108 |
| Pre-C *Lint Utility* ........ | 295 | 154 |
| Ptel *Binary File Transfer Program* ........ | 195 | 108 |

## polytron products

| | | |
|---|---|---|
| PolyBoost *Software Accelerator* ..... *Special Price* | 80 | 54 |
| PolyDesk III ........ | 99 | 72 |
| PolyDesk III Archivist ........ | 50 | 42 |
| PolyDesk III Cryptographer ........ | 50 | 42 |
| PolyDesk III Talk ........ | 70 | 52 |
| PolyLibrarian *Library Manager* ........ | 99 | 89 |
| PolyLibrarian II *Library Manager* ........ | 149 | 129 |
| PolyMake *UNIX-like Make Facility* ........ | 149 | 129 |
| PolyShell ........ *Special Price* | 149 | 105 |
| Polytron C Beautifier ........ | 50 | 45 |
| PolyXREF *Complete Cross Ref Utility* ........ | 219 | 185 |
| PolyXREF *One language only* ........ | 129 | 109 |
| PVCS Corporate *Version Control System* ........ | 395 | 329 |
| PVCS Personal ........ | 149 | 129 |

## program mgmt utilities

| | | |
|---|---|---|
| Interactive EASYFLOW *by Haventree* .. *New Version* | 150 | 125 |
| PrintQ *by Software Directions* ........ | 89 | 84 |
| Quilt Computing Combo *QMake & SRMS* ........ | 250 | 199 |
| Sapiens MAKE ........ | 179 | 155 |
| Sapiens MAKE & V8 ........ | 439 | 379 |
| Source Print *by Aldebaran Labs* ........ | 97 | 75 |
| TLIB *Version Control System by Burton* ........ | 100 | 89 |
| Tree Diagrammer *by Aldebaran Labs* ........ | 77 | 67 |

## sco products

| | | |
|---|---|---|
| Complete XENIX System V *by SCO* ........ | 1295 | 994 |
| Development System ........ | 595 | 499 |
| Operating System *Specify XT or AT* ........ | 595 | 499 |
| Text Processing Package ........ | 195 | 144 |
| Lyrix *by SCO* ........ | 595 | 449 |
| SCO Professional *1-2-3 Workalike for XENIX* ........ | 795 | 595 |
| SCO XENIX-NET ........ | 595 | 495 |
| XENIX System V 386 *by SCO* ........ | CALL | CALL |

## softcraft products

| | | |
|---|---|---|
| Btrieve *ISAM Mgr with No Royalties* ........ | 245 | 184 |
| Xtrieve *Query Utility* ........ | 245 | 184 |
| Report Option *for Xtrieve* ........ | 145 | 99 |
| Btrieve/N *for Networks* ........ | 595 | 454 |
| Xtrieve/N ........ | 595 | 454 |
| Report Option/N *for Xtrieve/N* ........ | 345 | 269 |
| XQL ........ *New* | 795 | CALL |

## text editors

| | | |
|---|---|---|
| Brief & dBrief Combo *from Solution Systems* ........ | 275 | CALL |
| Brief ........ | 195 | CALL |
| dBrief *Customizes Brief for dBASE III* ........ | 95 | CALL |
| de *by David Livshin* ........ | 75 | 65 |
| Epsilon *Emacs-like editor by Lugaru* ........ | 195 | 147 |
| KEDIT *by Mansfield Software* ........ | 125 | 98 |
| Micro/SPF *by PHASER SYSTEMS* ........ | 175 | 139 |
| Microsoft Word ........ | 450 | 269 |
| PC/VI *by Custom Software Systems* ........ | 149 | 99 |
| SPF/PC *by Command Technology Corp* ........ | CALL | CALL |
| Vedit Plus *by CompuView* ........ | 185 | 128 |

## turbo pascal utilities

| | | |
|---|---|---|
| ALICE *Interpreter by Software Channels* ........ | 95 | 66 |
| AZATAR DOS Toolkit *by AZATAR* ........ *New* | 95 | 85 |
| DOS/BIOS & Mouse Tools *by Quinn-Curtis* ........ | 75 | 67 |
| Flash-up *by Software Bottling* ........ *New* | 89 | 78 |
| Flash-up Developer's Toolbox ........ *New* | 49 | 45 |
| MACH 2 *for Turbo Pascal by Micro Help* ........ | 69 | 55 |
| MetraByte D/A Tools *by Quinn-Curtis* ........ | 100 | 89 |
| Science & Engrg Tools *by Quinn-Curtis* ........ | 75 | 67 |
| Screen Sculptor *by Software Bottling* ........ | 125 | 91 |
| Speed Screen *by Software Bottling* ........ | 35 | 32 |
| System Builder *by Royal American* .... *New Version* | 150 | 129 |
| IMPEX *Query Utility* ........ | 100 | 89 |
| Report Builder ........ *New Version* | 130 | 115 |
| TDebugPLUS *by TurboPower Software* ........ | 60 | 49 |
| Tmark *by Tangent Designs* ........ | 80 | 69 |
| Turbo EXTENDER *by TurboPower Software* ........ | 85 | 64 |
| Turbo OPTIMIZER *by TurboPower* ........ | 75 | 65 |
| *with Source Code* ........ | 125 | 98 |
| Turbo Professional *by Sunny Hill* ........ | 70 | 45 |
| TurboHALO *from IMSI* ........ | 95 | 75 |
| TurboPower Utilities *by TurboPower* ........ | 95 | 78 |
| TurboRef *by Gracon Services* ........ | 50 | 35 |
| TURBOsmith *Source Debugger by Visual Age* ........ | 99 | 89 |
| Universal Graphics Library *by Quinn-Curtis* ........ | 130 | 119 |

## wendin products

| | | |
|---|---|---|
| Operating System Toolbox ........ | 99 | 79 |
| PCNX *Operating system* ........ | 99 | 79 |
| PCVMS *Similar to VAX/VMS* ........ | 99 | 79 |
| Wendin-DOS *Multitasking DOS* ........ | 99 | 85 |
| Wendin-DOS Application Developer's Kit ........ | 99 | 85 |
| XTC *Text Editor w/Pascal source* ........ | 99 | 75 |

## xenix/unix products

| | | |
|---|---|---|
| Btrieve *ISAM File Mgr by SoftCraft* ........ | 595 | 454 |
| C-terp *by Gimpel, Specify compiler* ........ | 498 | 379 |
| c-tree *ISAM Mgr by FairCom* ........ | 395 | 315 |
| dBx *with Library Source by Desktop AI* ........ | 550 | 419 |
| DIRECTORY SHELL 286 *by American Mgmt Sys* ........ | 349 | 295 |
| DIRECTORY SHELL 386 *by American Mgmt Sys* . *New* | 495 | 415 |
| DOSIX *Console Version by Data Basics* ........ | 400 | 349 |
| DOSIX *User Version by Data Basics* ........ | 200 | 179 |
| Lugaru *Text Editor by Epsilon* ........ *New* | 195 | 147 |
| Micro Focus Products *See Micro Focus Section* | | |
| Microport Products *See Microport Section* | | |
| Microsoft Products *See Microsoft Section* | | |
| PANEL Plus *by Roundhill Computer Systems* ........ | 795 | 535 |
| REAL-TOOLS *Binary Version by PCT* ........ | 99 | 89 |
| *Library Source Version* ........ | 599 | 539 |
| *Complete Source Version* ........ | 999 | 729 |
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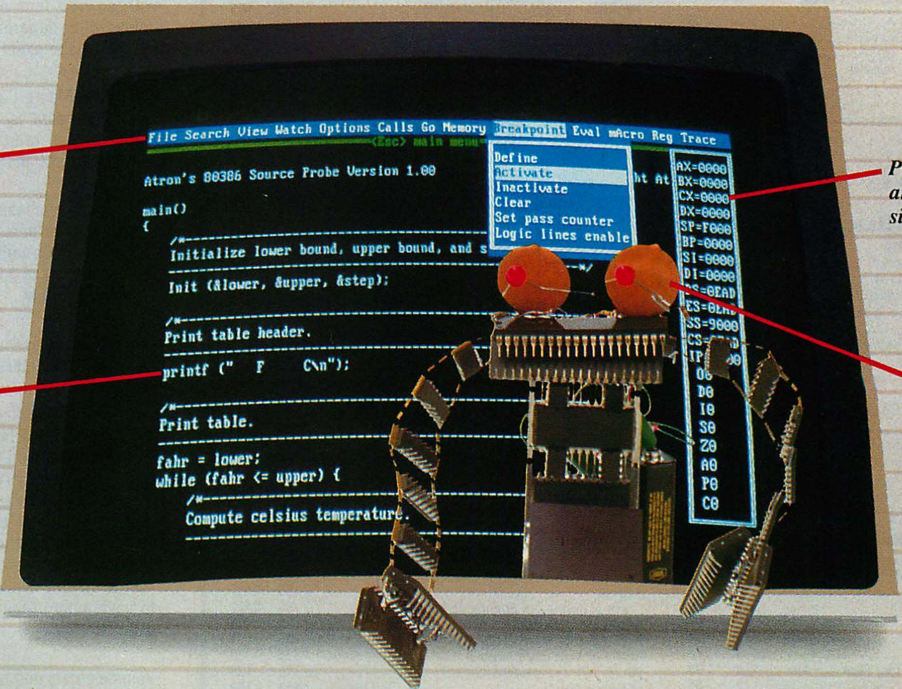


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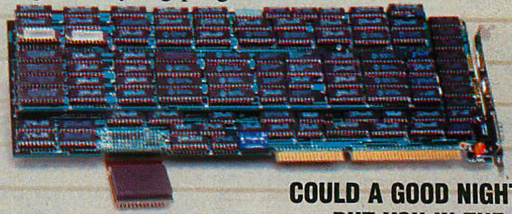

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NEW DIRECTIONS

# The EMS Odyssey

*The journey towards expanded memory is told in the page-turning tale of two specifications.*

When *PC Tech Journal* first learned that an expanded memory specification was under development, we were delighted at the prospect. We were less delighted, however, to learn that there would be two competing specifications for the technique; although this was far better than the dozens of paged memory schemes from the Z80 CP/M days, it still meant that two influential industry groups—Lotus, Intel, and Microsoft with their Expanded Memory Specification (EMS) on the one hand and AST, Ashton-Tate, and Quadram with their Enhanced Expanded Memory Specification (EEMS) on the other—would be competing for our memory dollars and leaving confusion in their wake.

It was too late to change their minds. Both AST and Intel were already committed to hardware and thus unlikely to alter course. I believed at the time that AST's approach would win out; it used more hardware registers and many more page frames that could also be in regular DOS memory, so users could gain greater benefit from the new add-in memory system.

AST had a strong history of leading the market for add-in memory boards. As a result, I assumed that AST's EEMS boards would also be the dominant factor and that EEMS would thus become the de facto standard. But mistakes by AST, combined with brilliant marketing and superb delivery by Intel, made mincemeat of my theory.

Intel's development of a retail market for its products was nothing short of masterful. Out of nowhere, the company's Personal Computer Enhancement Operation (PCEO) made "Genuine Intel" and "Above Board" recognizable trade names and established itself firmly in the traditional distribution channels. Math coprocessors, then Above Boards, came rushing through those channels, always with ready availability. In short, Intel sold Above Boards like hotcakes. Following AST's tradition, memory-only boards were followed by multifunction versions that incorporated the highly prized second serial port and the often extraneous parallel port.

In the meantime, AST helped Intel out in two ways. Although AST got the EEMS board to the market quickly, it stumbled by making the board a separate product instead of integrating EEMS capability into all its memory products. Therefore, AST had to distinguish between the two products to avoid buyer confusion (I'm not sure they succeeded; do you know whether RAMpage or ADvantage is the trade name for AST's EEMS boards? It's RAMpage). Intel had the advantage of selling a single product line. (AST eventually offered the integrated Premium line of boards, however.)

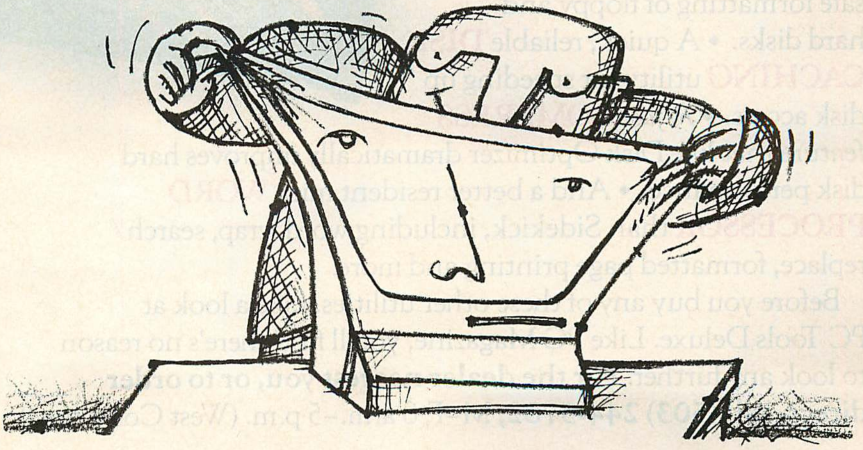
Worse, AST—the very company that had become synonymous with multifunction boards—did not offer a product directly competitive with the Above Board PS. (AST has since created competitive products across the board.)

Where does that leave us? We now have to consider a new problem: how do we cope with the installed base of so many Intel Above Boards?

**A NEW PROBLEM**

You might well ask why LIM EMS-compliant memory boards create a problem. The question is especially appropriate in light of the recently announced LIM EMS version 4.0, which, in fact, unifies the EMS and EEMS specifications. (For a detailed explanation of the original LIM EMS specification and how expanded memory works, see "Expandable Memory," Ted Mirecki, February 1986, p. 66.)

The Expanded Memory Specification version 4.0 incorporates several improvements over the original specification. To unify the EMS and EEMS specification, EMS 4.0 includes analogs for the EEMS functions 33 (get standard physical window array), 41 (get system physical window array), 42 (map page into system page frame), and 43 (get/set system mapping context). New functions provide operating system control over expanded memory, including 26 (get expanded memory hardware information), 28 (a suite of subfunctions for alternate map register manipulation), 29 (prepare EMS hardware for warm reboot), and 30 (enable/disable EMS functions 26 and 28). For programs, functions 22 (alter page map and jump) and 23 (alter page map and call)



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streamline program execution in EMS, while function 24 (move/exchange memory region) provides an EMS hardware-independent method for manipulating blocks of EMS memory. Additional functions support extended handle management and page allocation.

The new expanded memory specification is a terrific accomplishment. Congratulations to Lotus, Microsoft, Ashton-Tate, Quadram, and especially AST and Intel for working together to create a single specification. It appears to offer a good memory management alternative that will thrive for years to come, even in light of such complexities as Operating System/2 (OS/2).

So, if we have this important, useful, and standard specification for EMS, what then is the problem?

The improvement in the specification, the additions that take it up to and even beyond EEMS, does not change the fact that there is a critical mass of installed EMS boards lacking the hardware advantages needed to provide efficient support for such software as Quarterdeck's DESQview and Microsoft Windows 2.0. Both of these products are able to use EEMS memory to run programs, greatly increasing the number of programs that can be loaded simultaneously and allowing each one to use a more substantial portion of the 640KB DOS limit. In fact, the AST/DESQview bundle drives this point home. DESQview gains no execution benefit at all if your EMS solution is from Intel, and Windows 2.0 gains but little, getting far better results from EEMS-compatible memory and even more from IBM Expanded Memory Adapter (XMA) boards.

What may be little understood is that EMS 4.0 is a software, not a hardware, specification. It says nothing about how to build a memory board, only about how to write software that can exploit a particular abstract model of memory. This should be obvious from the fact that EMS can be supported on IBM's XMA board, an IBM-proprietary hardware design different from Above Boards or RAMpages.

To its credit, EMS 4.0 provides for multiple hardware register sets at the software interface level. That means software can *emulate* multiple hardware register sets even if they are not physically present in the hardware. Therefore, a board with a single set of hardware registers can be made to act the same as one with multiple sets.

That sounds very good. In fact, it sounds like even those who have invested in the original hardware set from Intel will be supported by new software that implements EMS 4.0. The picture is not quite that rosy, however. The original Above Boards are less than optimal for some important environments—notably DESQview and Windows 2.0. An important benefit of having lots of memory comes from getting concurrency by using programs such as DESQview and Windows 2.0. It is significant that both of these environments achieve concurrency on all types of desktop computers, including those based on the 8088 or 8086; EMS memory is an essential ingredient breathing life into such old iron.

However, *good* concurrency means switching between programs (tasks) *rapidly*. This is where the additional page frames come in so handy: they allow the operating system software to switch from one task to another simply by writing to I/O port registers, one time for every page frame to be mapped. With page frames in DOS's 640KB, large chunks of program can be mapped in and out quickly, enabling task switching to be handled with minimal overhead. Without page frames in DOS memory, however, the program must actually be moved from DOS memory to expanded memory.

And that's the rub. A board without additional page frames incurs high overhead whenever a task switch occurs. This, of course, is not just at the time the user switches from one program to another. A communications program that is running in the background must be able to gain control regularly—whenever data need to be sent or received. Ideally, this should happen while the user is happily calculating away in Lotus 1-2-3, without realizing that anything is going on in the background. As overhead rises, however, the performance of the foreground task will begin to drop.

Programs that use expanded memory for data will not encounter this performance reduction. Above Boards will continue to work well in such situations, regardless of the environment.

**WHAT'S EMS GOOD FOR?**

With OS/2 "just around the corner," and environments such as DESQview and Windows/386 giving every program running on a 386 machine its own 640KB space, why do we care about EMS? Is expanded memory going to fade away as an important technology?

Certainly. Although expanded memory will be compatible with the

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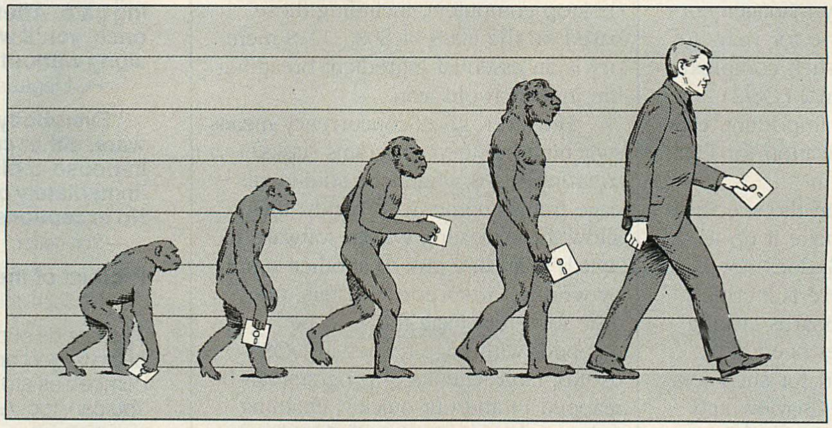

**"In this competitive world, a difference of just 10% can mean the distinction between pinstripe and primate."**

### What It Does

NetWare fault tolerance can be divided into two categories; software-based protection and hardware-based protection. Because Novell feels so strongly about the fundamental need for data protection, fault tolerance is included in all NetWare to some degree. Advanced NetWare 286 v2.1 contains features ensuring that files can be read after they are written, and redundant copies of directories are routinely made.

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new environments, new applications can better exploit the native memory of the processor and the memory model of the operating system. As time goes on, we will all prefer an environment with fewer, not more, attachments; the idea is to simplify the process of system installation and maintenance, not continue to complicate it.

That answer, however, fails to speak to two points. First, although OS/2 is *"just around* the corner," the corner is not yet in sight. The impact of OS/2 will not be felt until 1989—when all our favorite applications programs are in place. Until then, we still need more memory for data, and we still desire to have rapid context switching or concurrency.

Second, an enormous installed base of hardware cannot exploit OS/2 because its desktops do not sport the 286 or 386 processor, and there is no sign that sales of 8088 or 8086 machines are abating, although the rate of growth in that market is certainly level or falling. Because they cost so little and perform so many tasks in a satisfactory manner, the small, simple machines are still desirable.

Even IBM is catering to this situation. Although the PS/2 line is touted as the future, most analysts agree that the one million PS/2 units IBM claims to have delivered so far are mostly the low-end Model 30 and now the Model 25. These machines can benefit from expanded memory just as their predecessors, the PC and PC/XT, do.

For all those low-end machines, DESQview, or Windows combined with expanded memory (EEMS-style), represent a significant and cost-effective extension of productive life. Moreover, DESQview is in the enviable position of running on 8088, 8086, 80286, and 80386 systems, whereas OS/2 runs only on 286 or better. While a single version of DESQview runs on all processors and exploits the features of each, the Windows family consists of two products, one for the 386 and another for the other processors.

### MORE SHELLS AND EMS

Windows 2.0 is the version for those "non-386" processors. It is also the version that looks and feels like the OS/2 Presentation Manager, uses EMS, and serves as the "front end" for Windows/386. Microsoft has let *PC Tech Journal* explore beta versions of Windows 2.0.

On an 8-MHz IBM PC/AT 339 equipped with third-party EGA, the performance improvement of Windows 2.0

over 1.0x is immediately apparent. Most striking is the improvement in text performance, truly one of 1.0x's weakest points. Microsoft President Bill Gates recently boasted to us, rightfully so, that the performance of Windows on a *6-MHz* AT was at least as good as the performance of the Mac SE. That's not bad, considering that Windows is written for more than one hardware configuration and thus cannot be intimately attached, as is the Mac interface, to a single, common hardware set.

As usual, however, Windows and other programs remain limited by the performance of the graphics hardware. The difference in performance between the AT and a Compaq Deskpro 386 is, while evident, not as striking as the 1.0x to 2.0 difference. Thus, it remains clear that new graphics hardware with better capabilities and performance will be needed before the performance of a graphical user interface can peak.

Another shell program that uses EMS effectively is WordPerfect's Shell, included in the WordPerfect Library. Shell is a simple menu program that allows context switching between multiple programs, all of which it keeps resident in memory. Version 1.0 of the program uses what is left of 640KB after DOS is loaded for this purpose and can switch only among WordPerfect Corporation products; other programs must be exited to return to Shell. It does not allow concurrency.

Version 1.1 of Shell improves on the original version in several significant ways. First, it allows non-WPCORP programs to remain resident during a context switch. More important, the Shell 1.1 exploits expanded memory by swapping inactive programs from main memory to expanded memory. This simple technique allows programs to be loaded to the extent of expanded memory and it also allows very large programs (640KB less the size of DOS and Shell) to be loaded.

Again, Shell has no concurrency, as is the case with DESQview and Windows. However, the Shell program is simple to set up and use, and it is very inexpensive when considered in the context of the other programs included in the price ($129) of the Library (Calendar, Calculator, File Manager, Macro Editor, Notebook, and Program Editor). For simple situations in which multiple programs are frequently used but without the requirement for concurrency and multitasking, the Shell program is an elegant solution.

## VIDEO ADVANCES

The video market now has two new products, one delivered and one announced, that are bound to leave their mark. NEC America has a new monitor, and Compaq has announced one of the first Video Graphics Array (VGA) clones.

You can always tell that a product is successful when you see it wherever you go, and the NEC MultiSync monitor has indeed become ubiquitous. Now NEC has introduced its sequel, the MultiSync Plus. Sequels always get even more scrutiny than the original, but the new display fares very well.

In every way, the new version improves on the old: better styling, simpler set up with fewer switches, vastly improved documentation, more resolution, and a power switch on the front. NEC even includes two interface cables, one for EGA/RGB and the other for PS/2 VGA. Within five minutes, the Plus was out of the box and running VGA on my Compaq Deskpro 386.

The display is eerily flat. The colors matched the IBM display perfectly. The display area is a bit larger than IBM's 8513 monitor, so text characters seemed a tad fuzzier; the monitor's readability was no problem, however.

Only one fault mars an otherwise perfect production: the MultiSync Plus has a fan that is louder than the Deskpro 386. I feel sure that the fan noise will have to be muted before this unit will achieve the success of its older sibling.

Other than that, NEC has another winner on its hands.

Compaq, meanwhile, has entered the graphics market with its own VGA clone, called the Video Graphics System (VGS). It plugs in to both PC- and AT-compatible slots. In the 16-bit slots of a Deskpro or other compatible, the adapter operates on 16-bit words instead of the more usual bytes; the performance increase can be a factor of 3. Why IBM chose to make the VGA an 8-bit device, especially in light of its presence on all PS/2 system boards, is quite a mystery.

—*WF*

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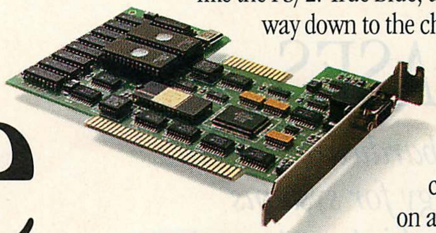

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# TECH RELEASES

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## SYSTEMS

Four members of the **Paragon** family of fully integrated, small footprint PCs from **American Mitac Corporation** have been released. Included on the system board of each Paragon system is a diskette-drive controller, serial port, parallel port, realtime clock with battery back-up, five full-size expansion slots, Phoenix BIOS, and a socket for an optional math coprocessor. MS-DOS 3.2 and GW-BASIC also are provided. All controls (on/off switch, reset switch for the CPU, control-panel LEDs, and keyboard connector) are located on the front panel. With a 14.8-by-6.2-by-16.2-inch footprint and designed with a 16-MHz, 32-bit 80386, the **Paragon 386** comes standard with a 1.2MB 5.25-inch diskette drive, a 40MB 5.25-inch hard disk (with a 28-ms average access time), 2MB RAM (expandable to 8MB), EGA-compatible adapter, and 12-inch EGA monitor. $4,895.

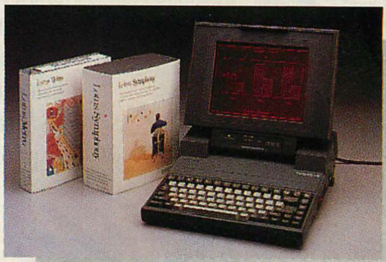
Based on a 12-MHz 80286, the **Paragon 286** can be switched to 8 MHz. The system comes standard with a 1.2MB 5.25-inch diskette drive, a 40MB hard-disk drive, 1MB memory on the system board (expandable to 4MB), and an on-board display controller with EGA, CGA, Hercules, and Plantronics emulation. An optional 12-inch EGA monitor that is custom designed to fit the small footprint of the Paragon 286 system is available. $3,350; with EGA monitor, $3,895.

The small footprint (13.4-by-5.5-by-16.2-inch) **Paragon 286S** has built-in EGA capability, 640KB RAM, 1.2MB diskette drive, and 40MB hard disk drive. The Paragon 286S uses an 10-MHz 80286 and has a socket for and optional 10-MHz 80287. $2,895; with 12-inch EGA monitor, $3,395.

The **Paragon 88** has an 8-MHz 8088-2 that is keyboard and hardware switchable to 4.77 MHz. The Paragon 88 has a video output that produces and automatically selects monochrome graphics, Hercules, Plantronics, or RGB color output. The standard configuration includes 768KB RAM (plus RAM disk program), two 360KB diskette drives, 84-key keyboard, and a 12-inch monitor. $1,195; optional 20MB hard disk, $499; optional EGA monitor, $589. *American Mitac Corporation, 410 E. Plumeria Drive, San Jose, CA 95134; 800/648-2287 (orders only); 408/988-0258*

**CIRCLE 301 ON READER SERVICE CARD**

A portable personal computer manufactured in the U.S. by **Toshiba American Inc.** has been announced. The **T3100/20** portable features an 8-MHz 80286 and a 20MB hard disk. The T3100/20 is equipped with 640KB memory (expandable to 2.6MB with optional memory card), built-in 720KB 3.5-inch diskette drive, high-resolution (640-by-400 pixels) 80-character-by-25-line, CGA-compatible gas plasma display, clock/calendar, and 110/220 VAC switch selectable power supply. Interface ports for an RGB video, RS-232C serial, parallel printer/external diskette drive, numeric keypad, and an expansion slot for optional modem or expansion chassis are standard. T3100/20, $4,699; 2MB memory expansion board, $1,699; 5.25-inch external diskette drive, $499; Floppy Link (cable for portable to PC exchange), $199; Hayes-compatible 300/1200-bps modem, $399; PC-compatible five slot expansion chassis, $999; interface card, $199. *Toshiba America, Inc., Information Systems Division, 9740 Irvine Blvd., Irvine, CA 92718; 800/457-7777; 714/583-3000*



*Toshiba America's 8-MHz T3100/20*

**CIRCLE 302 ON READER SERVICE CARD**

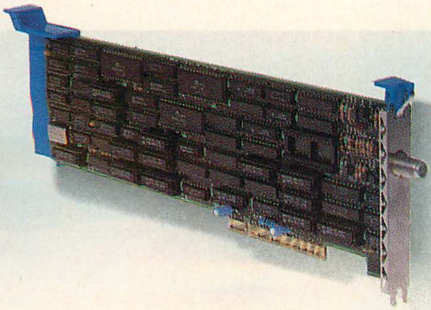
## CONNECTIONS

A 9,600-bps synchronous dial-up internal modem board from **GammaLink** for the IBM Personal System/2 has been introduced. The **GammaComm PS/2** modem features automatic dial, answer, and fall-back, which allows the modem to revert to 7,200, 4,800, or 2,400 bps, depending on the quality of the telephone line being used. $1,595. *GammaLink, 2452 Embarcadero Way, Palo Alto, CA 94303; 415/856-7421*

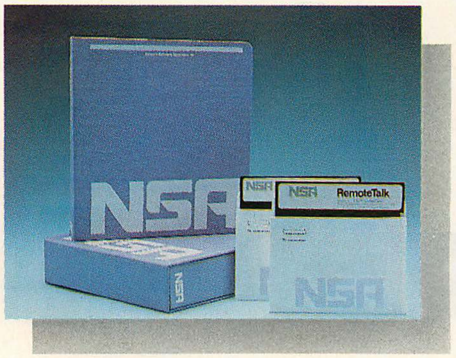
**CIRCLE 303 ON READER SERVICE CARD**

A line of communication products that provide 10-megabit-per-second (Mbps) Ethernet connectivity has been unveiled by **3Com Corporation**. The connection is made via unshielded twisted-pair telephone wire that allows a network administrator to assess the condition and appropriateness of any installed wiring and diagnose and pinpoint problem areas. The first of three products, the **PairTamer** is an adapter that allows the installation of IEEE 802.3 standard Ethernet on one of the unused pairs from the three or more pairs of unshielded twisted pair wires in a typical telephone wiring bundle. Both the telephone and network segment are plugged into the PairTamer, and the Ethernet (data) connection and telephone (voice) connection coexist without interference.

The second product is the **MultiConnect**, a repeater that allows connection of local area work groups to other wiring centers (and to other



LANpac II adapter card from Racore




NSA's RemoteTalk communications package

work groups) or to an Ethernet backbone. A base repeater contains slots for 15 modules and a total of 45 modules can be installed (using two MultiConnect expansion units) to accommodate a variety of wiring schemes. Any combination of coaxial, fiber optic, or twisted-pair wiring can be selected by installing the appropriate module.

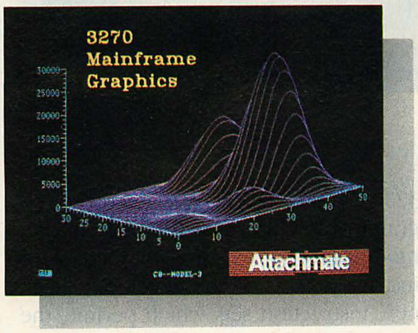
The third product is the **LanScanner**, a hand-held, battery-powered testing instrument that enables cable technicians and network administrators to measure wire characteristics and determine the ability of a particular wire to handle the data transmission. Set of two PairTamers (with interface card to the MultiConnect repeater), $325; MultiConnect, $1,095; expansion units, $1,095 each; optional interconnect cards for a connection to a thick Ethernet, $175; for connection to a thin Ethernet, $230; LanScanner, $995. *3Com Corporation, 3165 Kifer Road, Santa Clara, CA 95052-8145; 800/638-3266; 408/562-6400*

**CIRCLE 308 ON READER SERVICE CARD**

A Micro Channel version of its **LANpac II** local area network adapter card for the IBM Personal System/2 Models 50 and 60 has been announced by **Racore Computer Products, Inc.** LANpac II runs under Novell Advanced Network and supports applications written for either the IBM Token-Ring or PC Network. A maximum of 254 workstations can be connected in a network with larger network possible by configuring multiple cards in the file server. Workstations can be as far as 1,000 feet apart with repeaters available that can increase the distance to 10,000 feet. LANpac II can be configured in either a star or linear bus architecture. It uses an intelligent high-speed polling system to eliminate data collisions and retransmissions of data packets. All LANpac II cards offer a Remote Program Loading option to allow diskless workstations in which they are installed to boot without the need for a disk drive. $395. *Racore Computer Products, Inc., 170 Knowles Drive, Los Gatos, CA 95030; 800/325-1822; 408/374-8290*

**CIRCLE 305 ON READER SERVICE CARD**

The availability of 3179G vector graphics has been brought to the IBM Personal System/2 and PC environments. EXTRA! 3179G terminal emulation connectivity software from **Attachmate Corporation** offers up to four concurrent host sessions, running in either text or graphics mode. The resolution matching design of vector graphics converts 3179G terminal graphics into high-resolution PC images, with 16-color support. EXTRA! supports EGA and




Screen showing Attachmate's EXTRA! 3179G vector graphics

VGA and is compatible with GDDM (graphics data display manager) release 4.x as well as with all host graphic applications that support GDDM. EXTRA! gives users the advantage of choosing from over 70 output devices, such as Hewlett-Packard plotters, color printers from IBM and Epson, and slide generators from Polaroid. With the vector graphics option, graphic information is downloaded from the mainframe and the PC performs the graphic processing instead of the host. $695. *Attachmate Corporation, 3241 118th SE, Bellevue, WA 98005; 206/644-4010*

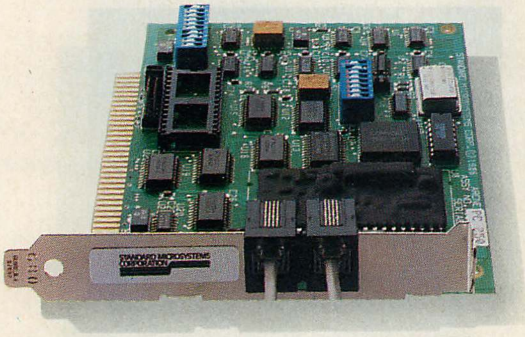
**CIRCLE 312 ON READER SERVICE CARD**

A program-to-program communications package from **Network Software Associates, Inc.** (NSA) has been designed for use with the IBM PC, Personal System/2, and compatibles operating in a Systems Network Architecture/synchronous data link control (SNA/SDLC) network environment. **AdaptSNA LU0** offers an applications-independent implementation of IBM's Logical Unit type 0 (LU0) protocol for DOS applications. Included are two levels of LU0 functions (called verbs). Basic verbs contain all the details required to control the entire LU0 protocol and the high-level verbs relieve the user from having to be concerned with most LU0 protocol details. An application development toolkit called the LU0 ASSIST (Applications Sub-System Interface and System Tutorial) provides a shell, programming language interface, and a learning and simulation facility. Package prices start at $50,000.

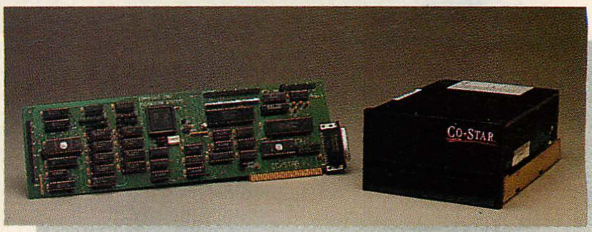
A PC-to-PC synchronous communications package offering both remote-control and concurrent background file-transfer capabilities has been announced by NSA. Called **RemoteTalk**, this product communicates via IBM's high-speed SDLC protocol. RemoteTalk operates at up to 19,200 bps on any IBM PC, PC/XT, or PC/AT with 192KB memory, an SDLC adapter board, and a synchronous modem. RemoteTalk, $295; AdaptCom SDLC adapter, $245; prices for high-speed (2,400- to 9,600-bps) synchronous modems (with an SDLC adapter on board) start at $795. *Network Software Associates, Inc., 22982 Mill Creek, Laguna Hills, CA 92653; 714/768-4013*

**CIRCLE 304 ON READER SERVICE CARD**

The IBM Micro Channel architecture is featured in **Eicon Technology Corporation**'s communications card, the **Single-Port Communications Coprocessor** (SPCC). Fully programmable, the SPCC can support asynchronous,



*Standard Microsystems' ARCNET-PC250 twisted-pair controller*




*Co-Star data storage subsystem from DSC Nestar Systems*

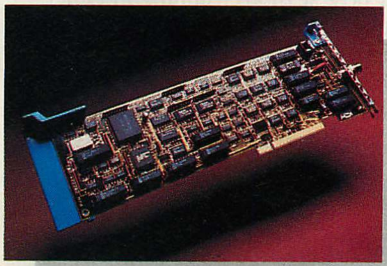
synchronous, and bit-oriented communication protocols. The SPCC's 68008 microprocessor performs all communications tasks, allowing the Personal System/2 to be used for other applications. It is available with memory configurations of either 256KB or 512KB and supports line speeds of up to 19,200 bps. One card inside any PS/2 on a LAN is capable of supporting as many as 254 concurrent users. Each PS/2 or PC can access the X.25 packet-switched network or SNA/SDLC network and maintain multiple sessions. The SPCC can be used with DOS 3.3, the IBM 3270 Workstation Program, and the upcoming OS/2. Prices start at $995. *Eicon Technology Corporation, 3452 Ashby Street, Montreal, Quebec, Canada H4R 2C1; 514/333-8543*

**CIRCLE 306 ON READER SERVICE CARD**

A family of ARCNET products for PC LANs using twisted-pair cabling is available from **Standard Microsystems Corporation**. This family features an **ARCNET-PC250** controller board that fits in an expansion slot in any PC. Multiple PCs are connected to a single twisted-pair segment in a daisy-chain or multidrop configuration. Network expansion is achieved by connecting twisted-pair segments with a two-port **Twisted Pair Repeater** and a twisted-pair network can be connected to an ARCNET *coaxial* network with a two-port **Twisted Pair Link**. An ARCNET fiber LAN can be connected to one of the coaxial cables with an Optical Repeater, allowing the three media to be intermixed in a single network. PC250, $295; Link, $375; Repeater, $375. *Standard Microsystems Corporation, 35 Marcus Blvd., Hauppauge, NY 11788; 516/273-3100*

**CIRCLE 311 ON READER SERVICE CARD**

The first two members of **AST Research, Inc.**'s family of 3270 emulation products designed for the IBM Personal System/2 Micro Channel, the IBM PC family, and AST Premium computers, are available. The **AST-CoaxIIA** and **AST-CoaxII** cards use a surface mount adapter and feature custom processors including the AST Cricket (a high-speed bit-slice communications processor) and the AST Co-Twin (a Coax/3270 protocol handler). AST-CoaxIIA and AST CoaxII provide IBM and IRMA compatibility at the hardware, API, and software levels. The products currently supports firmware instruction sets for IBM, IRMA, or AST-



*AST-CoaxIIA 3270 emulation board from AST*

3270 emulation. The AST microprogrammable chip set will enable future modification of existing soft-loadable instruction sets or the development of new instruction sets which permits the upgrading of firmware for support of new terminal devices and protocols such as LU6.2. $895. *AST Research, Inc., 2121 Alton Avenue, Irvine, CA 92714-4992; 714/863-1333*

**CIRCLE 307 ON READER SERVICE CARD**

A file server based on the Intel 80386 has been introduced by **Novell, Inc.** Called the **NetWare 386A**, the server comes with 1MB of memory on the system board (expandable to 4MB), and can support up to 2GB of disk storage with external disk drives. Included in the server are two 32-bit expansion slots, five 16-bit slots, and one 8-bit slot. The server supports Advanced NetWare 286 and SFT NetWare Levels I and II. The server supports the IBM Personal System/2 Models 25, 30, 50, and 60; PC/XT and PC/AT; and the SCS PCterminal, a diskless PC. Base configuration comes with 1MB memory, 1.2MB diskette drive, and a 42MB hard-disk drive. $6,295; with an 80MB hard-disk drive, $6,995; optional 60MB streaming cartridge tape drive, $2,995. *Novell, Inc., 122 E. 1700 South, Provo, UT 84601; 800/453-1267; 801/379-5900*

**CIRCLE 309 ON READER SERVICE CARD**

## PERIPHERALS

The **Co-Star**, a data storage subsystem using coprocessor technology, has been introduced by **DSC Nestar Systems, Inc.** The Co-Star subsystem, available in 80MB and 150MB capacities, is capable of independently performing disk-management operation and can access data from an IBM PC/XT or PC/AT at increased speed. The hard disk and intelligent disk controller subsystem includes 256KB RAM (expandable to 1MB) and coprocessor, which permits the CPU to run applications without interruption or memory overhead. Other features include intelligent buffering, print spooling, and optimization of file and disk space to reduce access delays and dispersion. 80MB capacity, $1,495; 150MB, $2,495. *DSC Nestar Systems, Inc., 1345 Shorebird Way, Mountain View, CA 94043; 415/969-1777*

**CIRCLE 318 ON READER SERVICE CARD**

An accelerator board for IBM PCs has been developed by **Microsoft Corporation**. Containing an 8-MHz 80286, the **MACH 20** board has interfaces for graphic input devices, a memory expansion option, and a multimedia disk-drive control option. Intended to extend the productive life of existing 8088-based PCs, the MACH 20 enables

*Continued on p. 41*

# Once again, Compaq raises the standard of performance for personal computers.

# This time by a factor of two…

# Introducing the two
# on earth

## The new COMPAQ DESKPRO 386/20™

Last year, we introduced the COMPAQ DESKPRO 386,™ the most advanced personal computer in the world. Now the world has two new benchmarks from the leader in high-performance personal computing. The new 20-MHz COMPAQ DESKPRO 386/20 and the 20-lb., 20-MHz COMPAQ PORTABLE 386 deliver system performance that can rival minicomputers. Plus they introduce advanced capabilities, without obsoleting your investment in software, hardware and training.

Our new computers employ an industry-standard 20-MHz 80386 microprocessor and sophisticated 32-bit architecture. But to make these two of the world's fastest PC's, we did more than just increase the clock speed.

For instance, both are built around a concurrent bus architecture. Two buses—one for memory and one for peripherals—eliminate information bottlenecks, allowing each component

It simply works better.

# most powerful PC's and off.


## and the new 20-MHz COMPAQ PORTABLE 386™

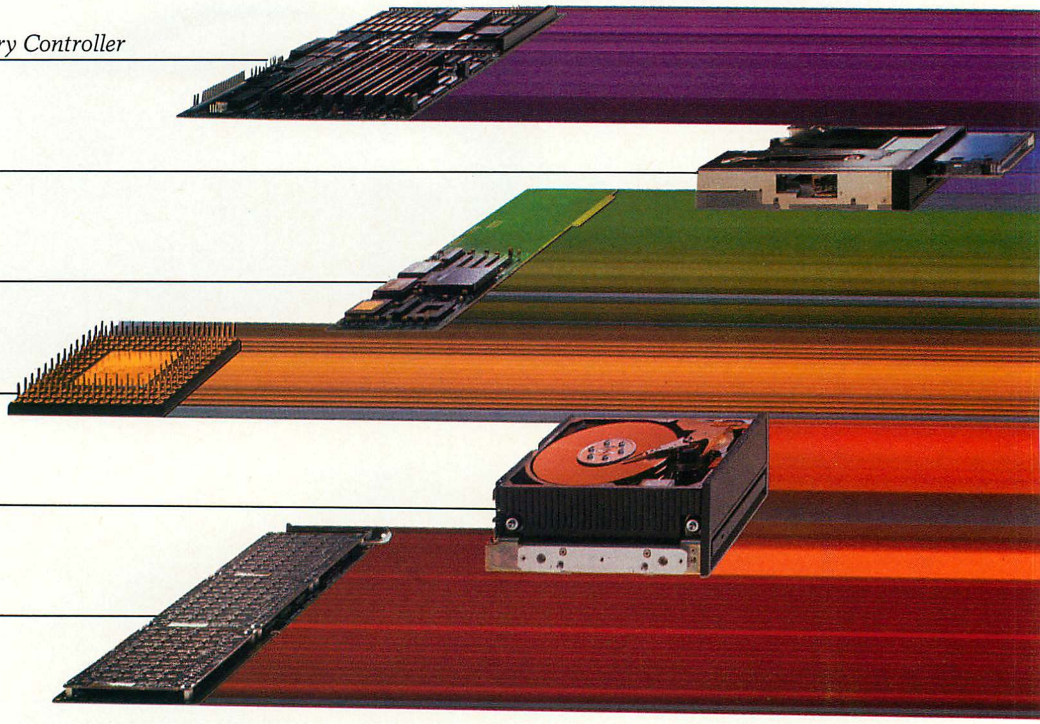
to run at its maximum speed. Together, they insure the highest system performance without sacrificing compatibility with industry-standard peripherals.

Both computers offer disk caching. Both offer the most memory and storage within their classes. Both let you run software being written to take advantage of 386 technology. And both run new MS-DOS®/BASIC Version 3.3 as published by Compaq. With it, our new portable and our new desktop can break the 32-megabyte limit on file sizes that handcuffs other PC's, allowing you to build files up to the size of your entire fixed disk drive.

*And from now until December 31, 1987, both computers come with a free package of new Microsoft® Windows/386 Presentation Manager.* It provides multitasking and switching capabilities with today's DOS applications to make you more productive. But that's just the beginning. To find out more, read on.

COMPAQ®

# The question wasn't but how to get the




## The most powerful personal computer in the world

The COMPAQ DESKPRO 386/20 is an impressive 50% faster than 16-MHz 386-based personal computers. Even more impressive is the fact that it's up to 25% faster than other 20-MHz 386's. That's because the processor is just one small part of how the COMPAQ DESKPRO 386/20 outperforms every other PC in the world today and even many minicomputers.

The big reason is the new COMPAQ Flexible Advanced Systems Architecture, which optimizes overall system throughput while maintaining full compatibility with industry-standard peripherals. It does this by combining an advanced memory caching scheme with memory and peripheral buses that operate concurrently.

Complementing the speed of the microprocessor is the new advanced 20-MHz Intel® 82385 Cache Memory Controller. Like an efficient secretary that keeps frequently used information close at hand, it allows the microprocessor to operate at 0-wait states 95% of the time.

While one bus handles these high-speed operations, another *simultaneously* handles periph-

It simply works better.

how to get to 20 MHz, most out of 20 MHz.

erals operating at the industry-standard 8 MHz.

This flexible approach allows you to dramatically increase system throughput while preserving your investment in monitors, disk drives, and expansion boards. It can also accommodate today's and tomorrow's most advanced peripherals without constraining their performance.

Take options like our new Weitek™ Coprocessor Board. Never before offered in a PC, it can increase the speed of calculation-intensive, engineering and scientific applications by a factor of six, giving the COMPAQ DESKPRO 386/20 the performance of a dedicated engineering workstation at a fraction of the cost.

Compaq also provides 130- and 300-Megabyte Fixed Disk Drives with some of the industry's fastest access times. And when used with disk caching software, they represent the highest-performance storage subsystems available.

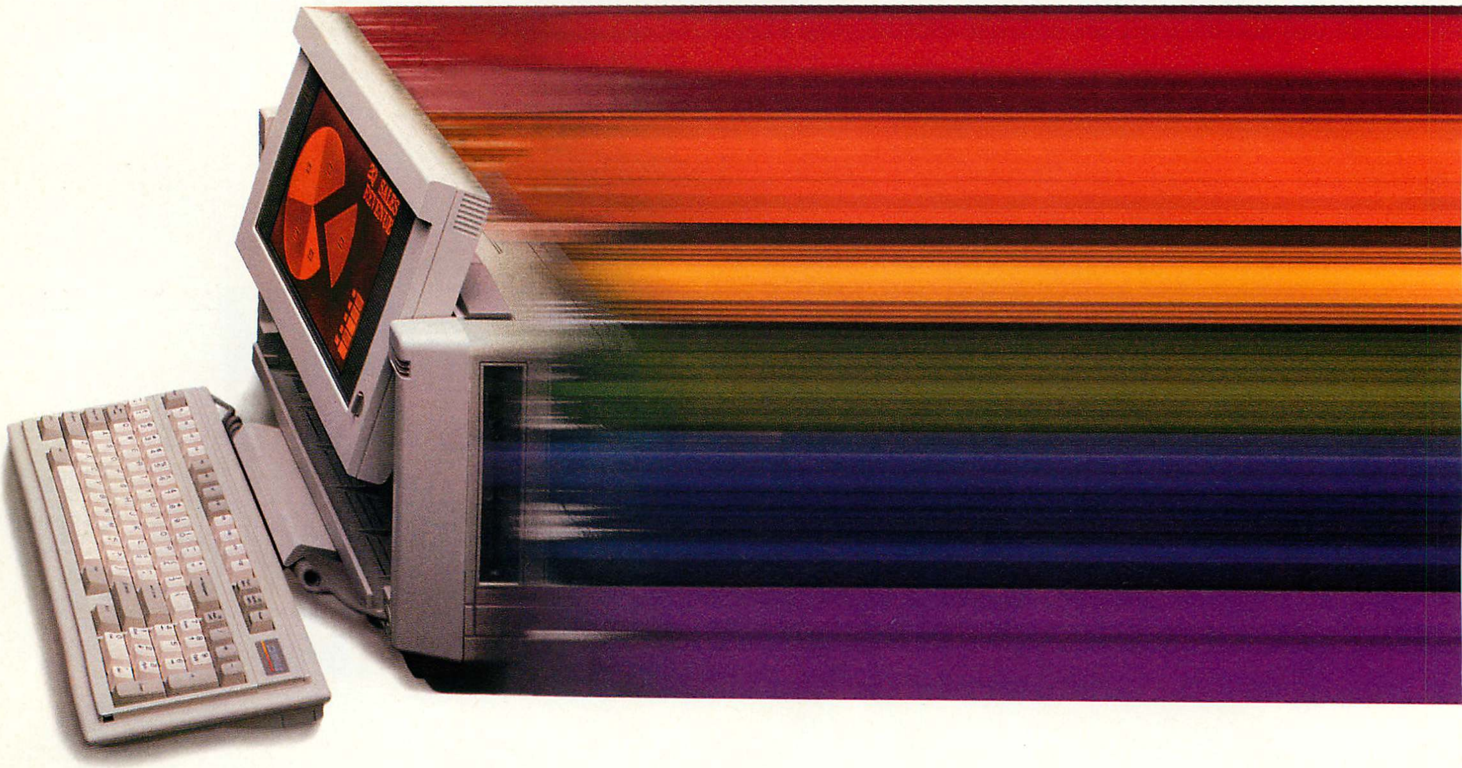
As for memory, Compaq offers 32-bit high-speed RAM. One full megabyte comes standard and is expandable to 16 megabytes without using an expansion slot. Plus, we included the COMPAQ Expanded Memory Manager. It supports the LIM standard so your software can break the 640-Kbyte barrier even before OS/2™ is released.

As tasks become more complex and users demand more advanced capabilities, Compaq responds by raising the standard of performance in personal computing.

COMPAQ

DESKPRO 386/20™

# Everyone expected Compaq
# But no one



## Pound for pound, it is the world's most powerful computer

Compaq has long been recognized as the world leader in both 80386 technology and portable computing. So it isn't surprising that we would combine the two.

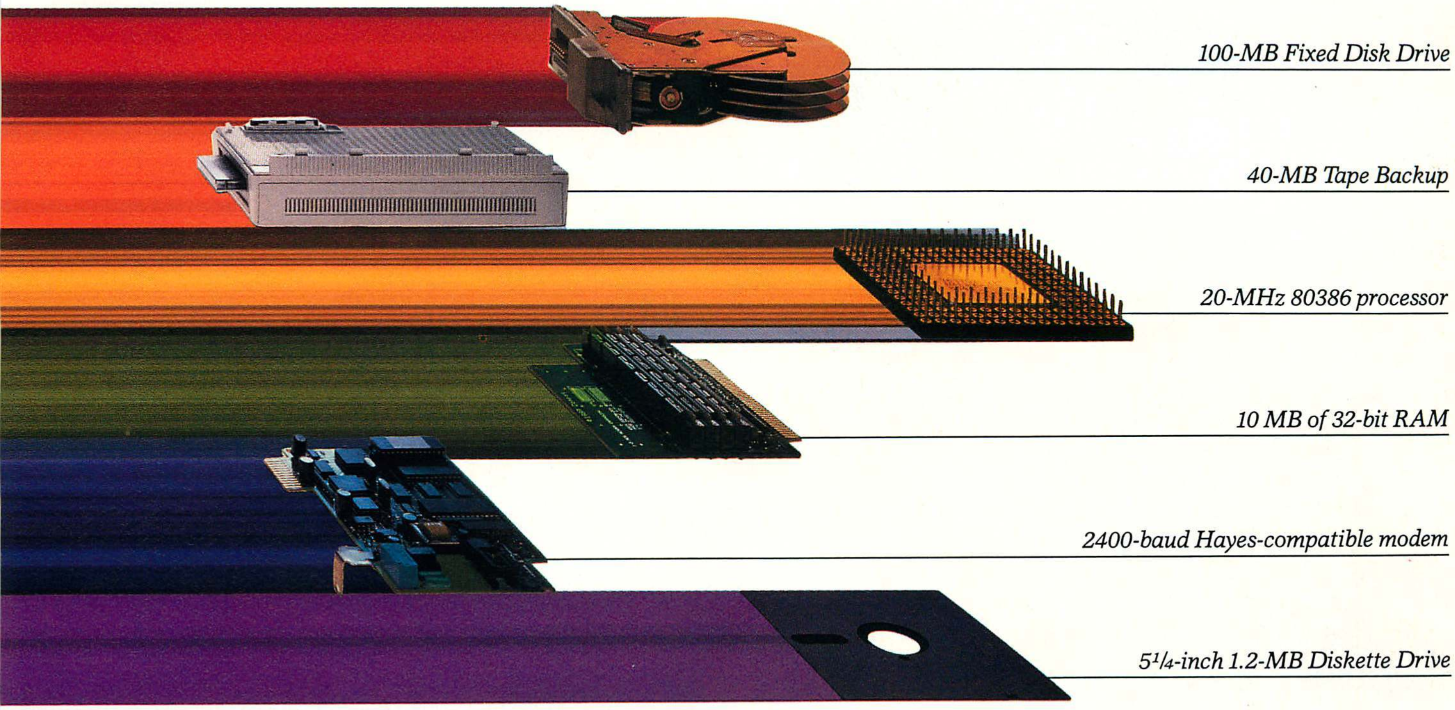
But no one expected the new COMPAQ PORTABLE 386 to run at 20 MHz. And no one even dreamed that it would offer 100 megabytes of storage, disk caching, and much, much more.

Our newest 20-lb. portable computer goes far beyond an 80386 microprocessor with a handle. It's not just the most advanced portable in the world. Pound for pound, it's the world's most powerful computer. Period.

Like the recent COMPAQ PORTABLE III,™ which changed the shape of full-function portable computing, the COMPAQ PORTABLE 386 makes no compromises. It offers more speed, memory, storage and features than any other portable PC. It runs your current software up to 25% faster than 16-MHz 386 PC's. Beyond that, its performance in calculation-intensive

It simply works better.

# to introduce a 386 portable PC.
# expected all this.




applications is increased even more when you add an optional 20-MHz 80387 coprocessor.

Memory? Get one megabyte of 32-bit, high-speed RAM standard or go as high as 10 MB internally. And like all of the COMPAQ 386-based PC's, it features the COMPAQ Expanded Memory Manager.

With our high-performance 100-megabyte internal fixed disk drive, you can actually fit 500 lbs. of data-filled pages into a 20-lb. PC, unsurpassed storage for a portable. If that's too much for you, we also offer a 40-megabyte model.

We've become famous for building desktop computer capabilities into our portables without leaving anything out. The COMPAQ PORTABLE 386 is more proof. It has a high-resolution, 640 × 400, 10-inch plasma display; a full-size, portable enhanced keyboard; two industry-standard expansion slots in a lightweight, optional plug-on unit; a choice between an optional 2400- or 1200-baud Hayes®-compatible modem; a full-size 5¼-inch 1.2-MB diskette drive; even an optional 40-MB tape backup.

These features, combined with the ultimate in portable performance, make the COMPAQ PORTABLE 386 the *biggest* PC this *small*.

COMPAQ

PORTABLE 386™

# Compaq moves you ahead without leaving you behind.


*Compaq* offers the most complete line of high-performance 386 solutions. They all run industry-standard software and hardware, protecting the investments you've already made.

At the same time you won't be left behind when other technologies become important. Multitask with existing applications using Microsoft Windows/386 Presentation Manager. Add VGA graphics if you wish. Run OS/2 when it's available. And now 3½-inch drives are even an option for our desktops.

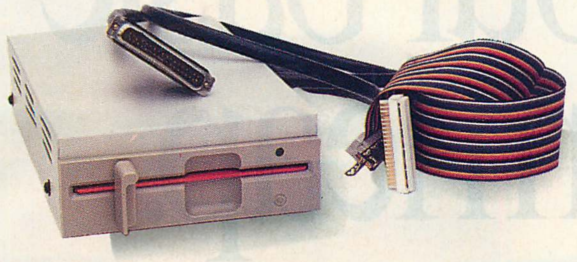
We optimize the most advanced technology while maintaining compatibility with the past, present and future. This makes COMPAQ PC's a wise decision for serious business users. Because at Compaq, we don't burn bridges, we build them.

See the COMPAQ DESKPRO 386/20 and COMPAQ PORTABLE 386 at an Authorized COMPAQ Computer Dealer. *And from now through December 31, 1987, get Microsoft Windows/386 Presentation Manager free when you buy a 386-based COMPAQ computer.* For more information, call 1-800-231-0900, Operator 40. In Canada, call 416-733-7876, Operator 40.

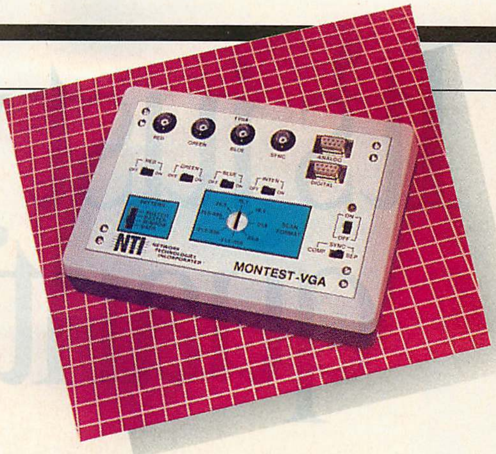


**COMPAQ®**

It simply works better.



External 5.25-inch 360KB diskette drive from Nth Group




Network Technologies' MONTEST-VGA portable pattern generator

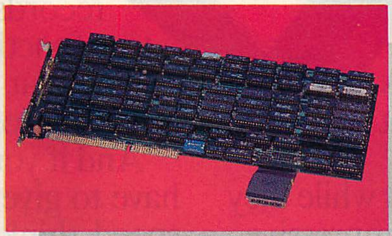
those machines to run the new generation of graphical software, including Microsoft Windows 2.0 and Microsoft OS/2. The board increases the speed of program execution two to six times on a standard PC or PC/XT, depending on the application being run. A 16-bit bus connects the 80286 bus to the PC system board and I/O channel resources. The 16KB of on-board cache memory provides the processor with fast access to frequently-used information. The MACH 20 includes the Microsoft's proprietary InPort chip and 9-pin connector to support the Microsoft Mouse and other InPort-equipped devices. $495.

The **MACH 20 Memory Plus** option supports up to 3.5MB of expanded memory and includes an expanded memory driver for programs that will support the Lotus/Intel/Microsoft expanded memory specification (LIM EMS) version 4.0. Microsoft will make available a custom version of MS-OS/2 with Memory Plus, guaranteeing compatibility with OS/2 applications. $395.

The **MACH 20 Disk Plus** option plugs directly into a connector on the MACH 20 and supports 1.2MB and 360KB 5.25-inch internal drives as well as 1.44MB and 720KB 3.5-inch internal drives, allowing PCs to read and write on normally incompatible media. $99.
*Microsoft Corporation, 16011 N.E. 36th Way, P.O. Box 97017, Redmond, WA 98073-9717; 800/426-9400; 206/882-8080*
**CIRCLE 314 ON READER SERVICE CARD**

A multifunction card for IBM Personal System/2 models 50 and 60 has been announced by **Megahertz Corporation**. The **ala CARD/2** comes standard with 2MB of expanded memory and an adapter for an additional 2MB. Port interface options include two serial ports, one serial port and one parallel port, a 1,200-bps or 2,400-bps Hayes-compatible modem, and a synchronous data link controller (SDLC). $995; two serial ports, $150; one serial port and one parallel port, $150; 1200-bps modem, $250; 2400-bps modem, $599.
*Megahertz Corporation, 2681 Parley's Way, Salt Lake City, UT 84109; 800/338-8726; 801/485-8857*
**CIRCLE 323 ON READER SERVICE CARD**

A hardware-assisted software debugger for 80386-based microcomputers from **Atron** has been announced. The **386/C PROBE** has the ability to do a qualified breakpoint, depending upon which routine is accessing specific locations. This ability makes it possible for the developer to set breakpoints upon modification of a variable, but allow it to trigger only if overwritten by a routine that should not be modifying it, not by one that should. The 386/C PROBE can detect the specific occurrence of up to four events in a specific realtime sequence. A trace feature saves program execution history and the programmer can decide which data to save or ignore while operating in realtime. The 386/C PROBE provides source-code level debugging for C (Microsoft, Lattice, and Borland), and Microsoft Pascal. It has 1MB of hidden and write-protected memory. $3,995.
*Atron, 20665 Fourth Street, Saratoga, CA 95070; 408/741-5900*
**CIRCLE 315 ON READER SERVICE CARD**



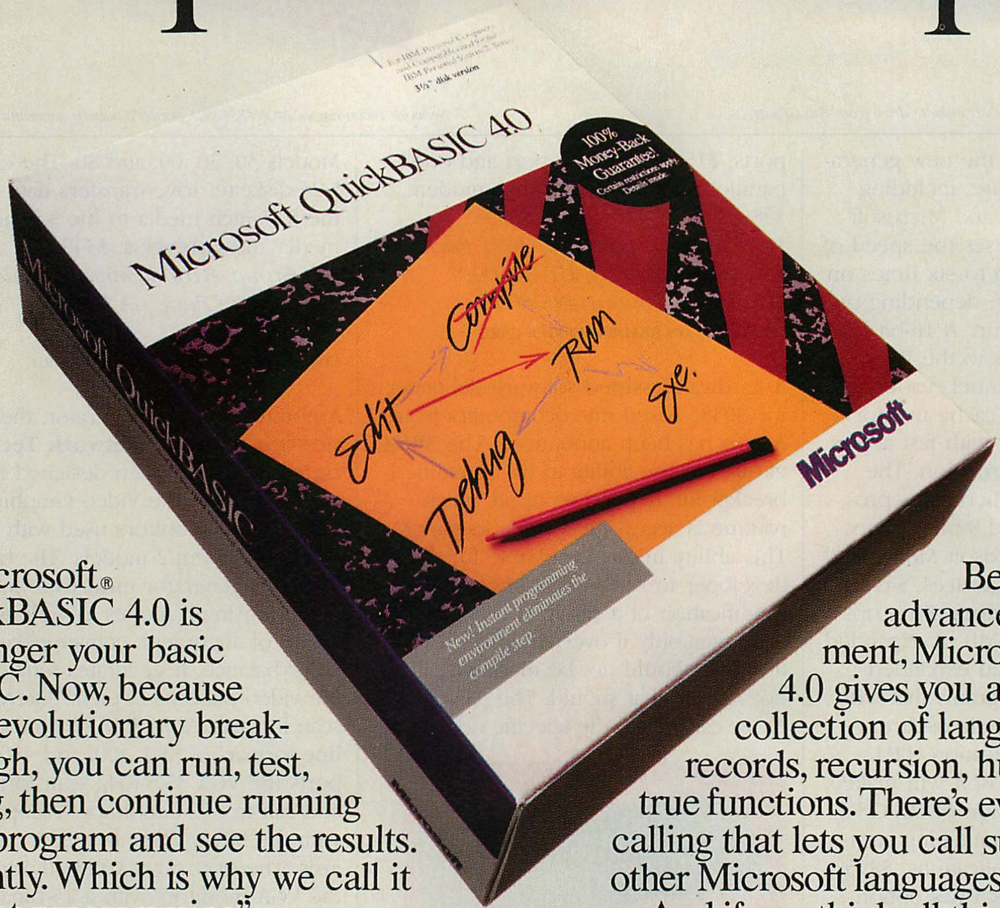
Atron's 386/C PROBE hardware-assisted software debugger

From the **Nth Group** comes its **External 5.25-inch 360KB Floppy Disk Drive** for the IBM Personal System/2 Models 30, 50, 60, and 80. The external 5.25-diskette drive transfers data from the 5.25-inch media to the 3.5-inch media and vice versa. $349.
*Nth Group, 8100 Remmet Avenue, Unit 10, Canoga Park, CA 91304; 818/883-5506*
**CIRCLE 319 ON READER SERVICE CARD**

A portable pattern generator, the **MONTEST-VGA** from **Network Technologies, Inc.**, has been designed for operation with the Video Graphics Array (VGA) monitors used with the Personal System/2 models. The battery-powered generator ensures monitor operation in all modes as well as verification of alignment, convergence, and color balance. It generates four different video patterns at eight different scan formats. At 31.5 KHz, it provides line formats of 350, 400, and 480; supports the VGA 35.5-KHz scan format; and can test TTL monitors compatible with the MDA, CGA, and EGA standards. The MONTEST-VGA directly drives the VGA monitors with a 15-pin, high-density D connector. $895.
*Network Technologies, Inc., 19145 Elizabeth Street, Aurora, OH 44202; 800/742-8324; 216/543-1646*
**CIRCLE 320 ON READER SERVICE CARD**

Marketed and sold by **CSSL, Inc.**, the **Awesome I/O Card for PS/2** enhances I/O speed and memory capabilities of the IBM Personal System/2 Models 50. With technology adaptable to the Micro Channel architecture, this card decreases the Model 50's average access time to less than five milliseconds, while doubling disk capacity. Other features include error correction code, large-volume support, multiple partitions, and file fragmentation control. The card's Heuristic Adaptive I/O Controller (HAC) self-configures the subsystem, allowing interception and storing of commonly used data from the disk. A solid-state disk accelerator

# It's just your basic quantum leap.




Microsoft® QuickBASIC 4.0 is no longer your basic BASIC. Now, because of a revolutionary breakthrough, you can run, test, debug, then continue running your program and see the results. Instantly. Which is why we call it "instant programming."

Other compilers make you wait while they compile your program at an unimpressive rate of 12,000 lines per minute. But Microsoft QuickBASIC 4.0 translates your program into executable code at a breathtaking 150,000 lines per minute. You get all the speed you can possibly use right when you need it. While you're developing your program.

And for the first time in BASIC, you'll find the most sophisticated debugging tools around. Like the freedom to change a running program on the fly. Without restarting. And you also get instant syntax checking, watch expressions, even runtime type checking.

Besides all these advances in the environment, Microsoft QuickBASIC 4.0 gives you a sophisticated collection of language extensions: records, recursion, huge arrays and true functions. There's even interlanguage calling that lets you call subroutines from other Microsoft languages.

And if you think all this means you might have to give up phenomenal execution speed, think again. Microsoft QuickBASIC 4.0 gives high performance executable code that's the fastest anywhere.

About the only thing that isn't more advanced in Microsoft QuickBASIC 4.0 is the price.

It's still just $99. And it's still backed with a 30-day money back guarantee. Microsoft QuickBASIC 4.0.

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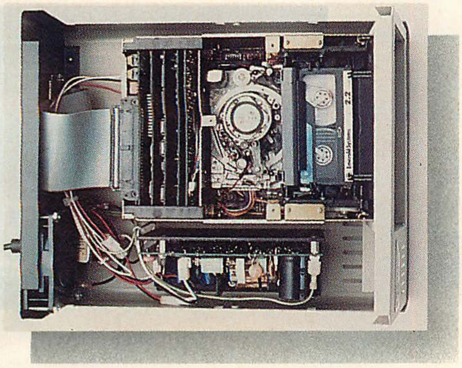
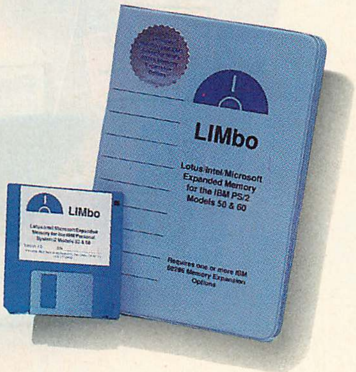


Internal view of Emerald Systems' VAST Device tape back-up system

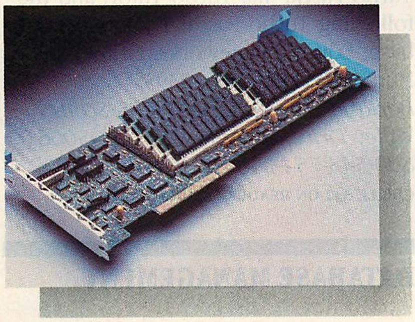



Vericomp's LIMbo expanded memory manager for the IBM PS/2

is included that allows an additional 256KB or 512KB of nonvolatile CMOS-RAM for disk acceleration and is driven by an on-board battery pack, keeping all RAM on-line to maintain the most-used drive access patterns. $949.
*CSSL, Inc., 909 Electric Avenue, Suite 202, Seal Beach, CA 90740; 213/493-2471*
**CIRCLE 317 ON READER SERVICE CARD**

Using its proprietary Virtual Archival Storage Technology (VAST), **Emerald Systems** has produced the **VAST Device**, a tape backup system using "Advanced Helical Scan Recording" techniques that permits up to 2.2GB of data storage on a single tape cassette the size of a pocket calculator. The Advanced Helical Scan Recording Technology writes data to tape in adjacent narrow tracks (stripes) at an acute angle of about 5 degrees producing an effective track length of 3.037 inches. Three heads (read, write, and servo) are mounted on a rotating drum around which the tape is wrapped. The combination of low tensions and other mechanical forces realize a long life for both media and tape transport. With the VAST Device, processing those applications where more than 250MB is required becomes possible on a desktop computer. The VAST Device uses a proprietary error correction code (ECC) to ensure high, long-term data reliability. A read/verify after write occurs for each track of data. VAST cassettes are available in 250MB, 500MB, 1GB, and 2.2GB capacities. $6,995.
*Emerald Systems Corporation, 4757 Morena Blvd., San Diego, CA 92117; 800/553-4030; 619/270-1994*
**CIRCLE 322 ON READER SERVICE CARD**

A multifunction memory board for the Personal System/2 Models 50, 60, and 80 has been introduced by **Tecmar, Inc.** Called the **MicroRAM**, this board includes extended memory support for the 80286 and 80386 and is compatible with the Lotus/Intel/Microsoft expanded memory specification (LIM EMS). The MicroRAM accommodates both expanded and extended memory modes without requiring hardware reconfiguration. The MicroRAM takes advantage of the IBM Micro Channel architecture, including full compatibility with the Programmable Option Select feature, support for enhanced dynamic memory reallocation of bad segments, and compatibility with IBM's 80286 Memory Expansion Option. Using socketed single in-line memory modules (SIMMs) for a true single-slot design, MicroRAM is available in a memory-only configuration. The **MicroRAM+2** includes two serial communication ports. Prices range from $495 for the MicroRAM with 512KB of memory to $5,495 for the MicroRAM+2 with 8MB of memory and two serial ports.
*Tecmar, Inc., 6225 Cochran Road, Solon, OH 44139-3377; 216/349-0600*
**CIRCLE 325 ON READER SERVICE CARD**

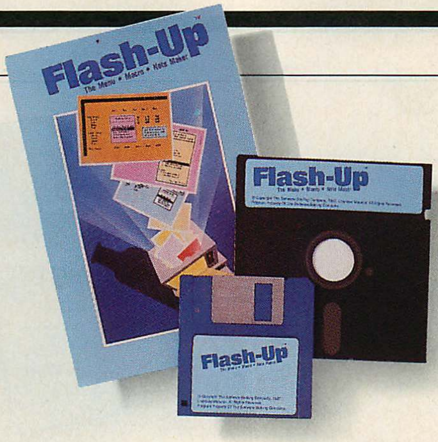


MicroRAM multifunction memory board from Tecmar

## SOFTWARE DEVELOPMENT

Expanded memory capability for the IBM Personal System/2 Models 50 and 60 is made possible by **LIMbo** from **Vericomp**. LIMbo transforms banks of memory on IBM's 80286 Memory Expansion Option board into high-speed expanded memory Lotus/Intel/Microsoft expanded memory specification (LIM EMS). It is an expanded memory manager (EMM) that makes use of the page-mapping capability of the 80286 Memory Expansion Option, a 2MB board available from IBM (Part No. 6450344) for the PS/2 Models 50 and 60. LIM EMS version 3.2 is supported for up to 8MB of expanded memory on the 80286 Expanded Memory Option board. LIMbo coexists with IBM's RAM-disk driver, VDISK, and its disk-caching program, IBMCACHE. LIMbo allows the user to specify the amount of available memory in the 80286 Memory Expansion Option to be used for EMS applications, leaving the rest of the memory available for use as extended memory by other programs. $49.95.
*Vericomp, 8825 Aero Drive, Suite 210, San Diego, CA 92123; 800/876-0400; 619/277-0400*
**CIRCLE 331 ON READER SERVICE CARD**

**Lotus Development Corporation**, **Intel Corporation**, and **Microsoft Corporation** have together announced a revision of the **Lotus/Intel/Microsoft expanded memory specification** (LIM EMS) from version 3.2, introduced in 1985, to **version 4.0.** Applications written to the LIM EMS 4.0 can run on existing EMS 3.2, AST/Quadram/Ashton-Tate Enhanced EMS (AQA EEMS) or IBM Expanded Memory Adapter (XMA) hardware, although these boards will require new device drivers. Existing emulation programs based on the 80386's page-mapping facilities can be upgraded to EMS 4.0. Applications written to EMS 3.2 are upwards compatible with EMS 4.0. Software developers can access the features of the new EMS specification through 15 new functions and 39 new subfunctions. Some of the capabilities of LIM EMS 4.0, such as multitasking and program code execution in expanded memory, are equivalent to capabilities




*Flash-Up, a macro, menu, and note maker, from Software Bottling Company*


*Screen shot of Information Builders' PC/FOCUS 3.0 operating shell*

originally developed by AST for its EEMS. AST has indicated that it will fully support EMS 4.0.

*Lotus Development Corporation, 55 Cambridge Parkway, Cambridge, MA 02142; 617/577-8580*

**CIRCLE 327 ON READER SERVICE CARD**

*Intel Corporation, Mail stop CO3-07, 5200 N.E. Elam Young Parkway, Hillsboro, OR 97124-6497; 800/538-3373; 503/681-8080*

**CIRCLE 328 ON READER SERVICE CARD**

*Microsoft Corporation, 16011 N.E. 36th Way, P.O. Box 97017, Redmond, WA 98073-9717; 800/426-9400; 206/882-8080*

**CIRCLE 329 ON READER SERVICE CARD**

Shipment has begun on the **Flash-Up Developer's Toolbox**, a **Flash-Up** add-on product from **The Software Bottling Company**. Flash-Up is a memory-resident macro, menu, and note maker. The Flash-Up Developer's Toolbox allows programmers incorporate macros, menus, and notes into their applications. The Toolbox contains a Programming Language Interface to such languages as dBASE, C, 1-2-3, Macros, DOS, assembly, BASIC, and Pascal. The Toolbox has a royalty-free runtime module that lets developers distribute Flash-Up macros and windows to others without paying extra royalty or runtime fees. Flash-Up, $89; Flash-Up Developer's Toolbox, $49.

*The Software Bottling Company, 6600 Long Island Expressway, Maspeth, NY 11378; 718/458-3700*

**CIRCLE 330 ON READER SERVICE CARD**

An enhanced version of **Turbo Pascal** has been announced by **Borland International**. Now able to compile as many as 27,000 lines per minute on an 8-MHz IBM PC/AT, **version 4.0** breaks the 64KB program size barrier, supporting programs up to the memory limit of DOS. Turbo Pascal now supports units, with automatic execution of initialization and exit codes for each nested unit up to eight levels deep. Other features include variable and value typecasting, DOS I/O redirection, support for tree-structured directories, and BlockRead/Write on untyped (binary) files. Turbo Pascal 4.0 offers improved code generation with constant folding, unused code removal, and optimized use of registers. Code written for Turbo Pascal 3.0 will compile with minor modifications under 4.0. Additional language features include support for inline statements and macros, and a powerful assembly language interface that allows linking in .OBJ files. $99; Developer's Library (includes Turbo Pascal 4.0, Turbo Tutor, and the following Turbo Pascal Toolboxes: Database, Editor, Gameworks, Graphix, and Numerical Methods), $395.

*Borland International, 4585 Scotts Valley Drive, Scotts Valley, CA 95066; 800/543-7543; 408/438-840*

**CIRCLE 332 ON READER SERVICE CARD**

## DATABASE MANAGEMENT

An updated version of **PC/FOCUS-Multiuser** by **Information Builders, Inc.** for use with LANs has been announced. **Release 3.0** offers a menu-driven interface and enhanced functionality. Features include additional windowing interfaces while providing new 3-D graphics, powerful communications capabilities and improved micro-to-mainframe connections. Release 3.0 contains a menu-based operating shell controlling the entire PC/FOCUS-Multiuser work session. The window-driven shell lists all the processing options and facilities of the product. Prices range from $1,995 to $6,000 based on the number of users.

*Information Builders, Inc., 1250 Broadway, New York, NY 10001; 212/736-4433*

**CIRCLE 339 ON READER SERVICE CARD**

A source-code level dBASE debugger has been announced by **HJS Research, Inc.** Designed for use with dBASE III PLUS and FOXBASE+ 2.0, **dBUG** is fully interactive, permitting programmers to debug applications as they execute. dBUG allows the user to enter breakpoints, which permit the program to execute until the breakpoint is encountered. After the breakpoint is hit, the program is suspended and the source code is displayed. Breakpoints may be entered at any location in the code. Watchpoints are used to display variables along with their values. If the program alters a variable, the watch window is updated to reflect the change. Tracepoints can be set for any variable or field, causing the program to break if the value changes, for ease of finding errant variable assignments. Separate windows are provided for source code, debugger commands, variables, calling sequence and dBASE output. The user retains strict control over the program through commands such as step, run, break, watch, and trace. $195.

*Interactive debugging screen from HJS Research's dBUG*

*HJS Research, Inc., Cedar Court, Suite 6162, Monmouth Junction, NJ 08852; 800/323-1809; in California, 213/492-1750*

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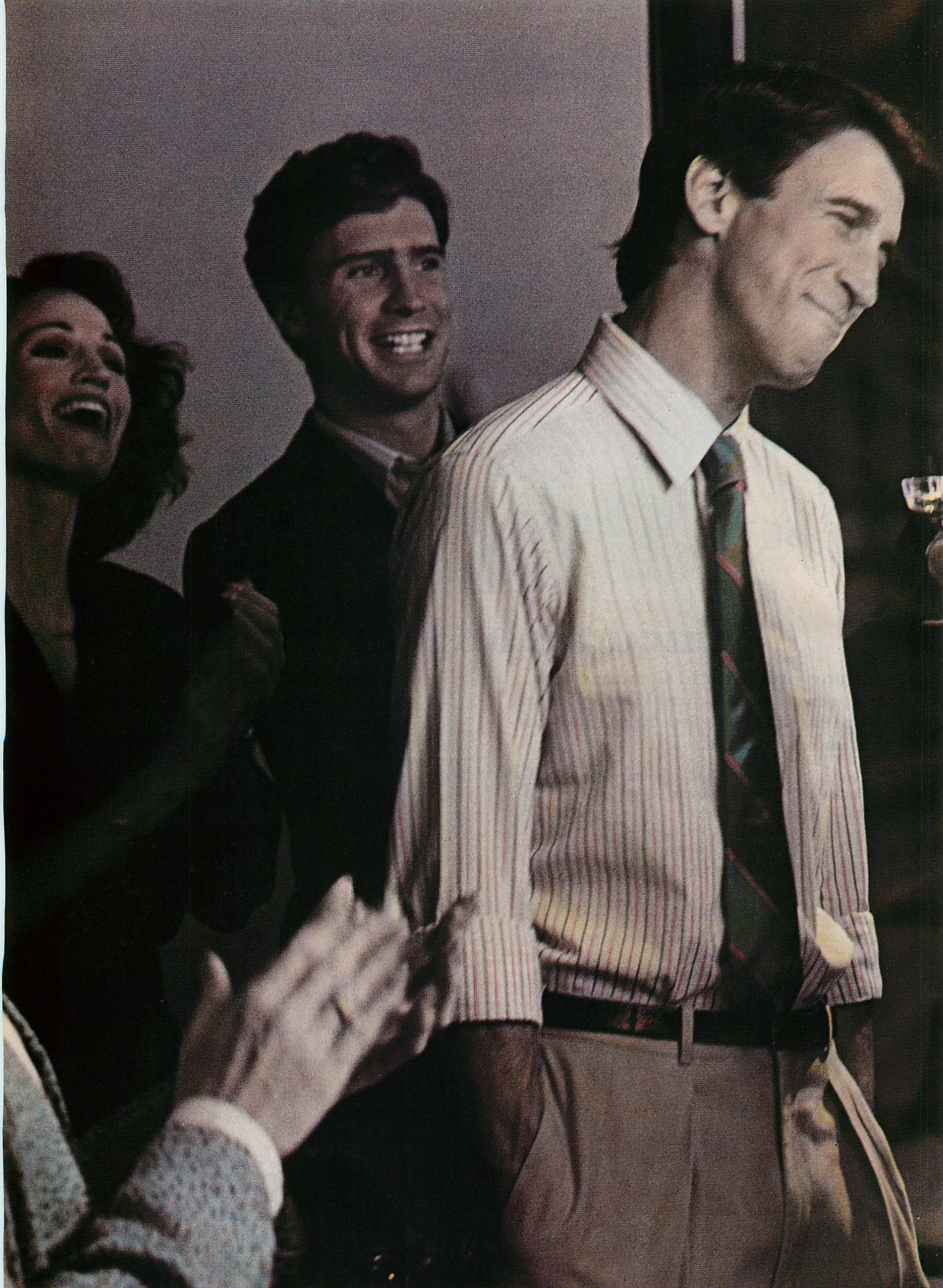
*The material that appears in Tech Releases is based on vendor-supplied information. These products have not been reviewed by the* PC Tech Journal *editorial staff.*



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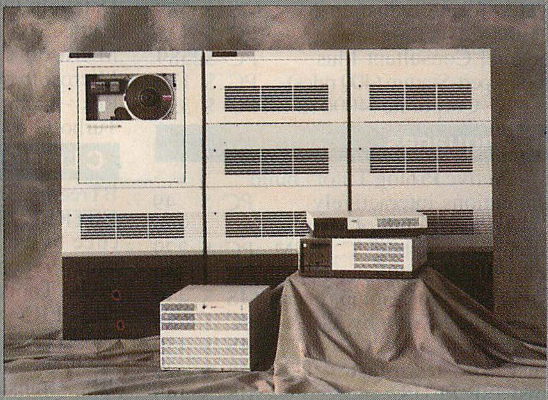

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| Datalight Optimum - C | MS | $ 99 |
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| Turbo C by Borland | PC | $ 69 |

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TECH NOTEBOOK 83

TED MIRECKI

# DOS Memory Allocation

*A practical use for this function might be in an intelligent TSR program that can deinstall itself from anywhere in memory.*

One of the major functions of an operating system is to control the use of memory by application processes. The data structures that DOS uses to do this were described in Technical Notebook 81 ("DOS Memory Control," Ted Mirecki, October 1987, p. 45). Basically, DOS constructs a singly linked list of unallocated memory blocks and at every request for memory, it searches the list to find the next block available for allocation. Ever since DOS version 3.0, there has been a method to control the *memory-allocation strategy*, the procedure DOS uses to determine where in this chain to allocate a newly requested block. The three strategies available to DOS are *first fit*, *best fit*, and *last fit*.

With the first-fit strategy, DOS searches the chain of memory blocks from the lowest address to the highest, allocating the requested memory from the first block large enough to satisfy the request. This was the only available strategy under DOS 2.x and is the default established by DOS 3.x at system initialization. Under best fit, DOS searches all the memory blocks and allocates from the smallest one that is large enough. When the last-fit strategy is in effect, DOS searches the chain of memory blocks from high address to low address, and allocates memory from the highest block that is large enough to satisfy the request. If this block is larger than the request, the memory is allocated from the high end of the block; in both of the other two cases, memory allocation always takes place from the low end.

The strategy can be queried or changed with function 58H of interrupt 21H. It is documented by Microsoft in the *MS-DOS Programmer's Guide*, but it is not cited by IBM in the *DOS Technical Reference*. Interestingly enough, this turns out to be the only function in the IBM manual that is given the label, "Used internally by DOS"; all of the other undocumented functions are listed as "Reserved for DOS."

The calling sequence for this function is as follows: AH:, 58H; AL:, 0 to get the allocation strategy, 1 to set it; BL:, if setting strategy, 0 for first fit, 1 for best fit, and 2 for last fit.

The strategy code is taken from BL, not BX as documented in Microsoft manuals and several books. When getting the allocation strategy (AL = 0), the input value in BL is ignored, and the system returns 0, 1, or 2 in the AX register to indicate the strategy that is currently in effect.

On return, the carry flag is set if an error occurs. The only error returned by this function is AX = 1, *Invalid Function*, if the input value in AL was not 0 or 1. The value in BL is not checked, and any value greater than 1 has the same effect as 2. However, the next "get strategy" call returns the last code set, not the effective value. Therefore, a program that queries the strategy should test not for the specific value of 2 but for any value greater than 1 to determine whether or not the last-fit strategy is being implemented.

The difference between first-fit and best-fit strategies is significant only if there are multiple free memory blocks. DOS always combines adjacent free blocks into one, so multiple blocks exist only if they are nonadjacent. Deallocating a resident program's environment, as suggested by the IBM *DOS Technical Reference* for interrupt 27H and function 31H, can leave such unallocated holes in memory. However, a fragmented memory space occurs more typically in a multitasking system. It is only under unusual circumstances that this would occur in a single-tasking system.

The last-fit strategy, however, does differ from the default behavior even with one free memory block, so long as the requested block is smaller than the memory available. In that case, the allocation is made out of the top of the free block. To illustrate this effect, the following program is entered and executed from within the DEBUG program:

```
MOV AX,5801
MOV BX,2
INT 21
INT 20
```

Now exit debug and run CHKDSK. The total available memory reported is lower than usual—for example, on a 640KB system, the total might be 655,120 bytes instead of the usual 655,360 (640 times 1,024). The exact reduction depends on the size of the environment block.

When the DOS command processor loads a program, it allocates two memory blocks for it. First, it allocates a block of sufficient size to hold a copy of the environment containing the strings specifying COMSPEC, PATH, PROMPT, and any variables established with SET commands. In a last-fit strategy, this is allocated at the top of memory. Second, the largest free block is allocated for the program itself. CHKDSK reports the total available memory as the end of the block in which it is executing, based on the assumption that the largest free block would extend to the top of memory.

Because the loader always allocates the entire largest free block to a program, the allocation strategy usually has no effect on the location of a program in memory, except when several blocks of the same maximum size exist; then the program is loaded into the highest block under the last-fit strategy and into the lowest block otherwise.

A practical use for this function might be in an intelligent terminate-and-stay-resident (TSR) program that can deinstall itself from anywhere in memory, even if it is not the last program loaded. On a subsequent reinstall, this program could deploy a best-fit strategy in order to locate an optimally sized memory hole and relocate its resident portion there, instead of having it installed wherever DOS has happened to load it.

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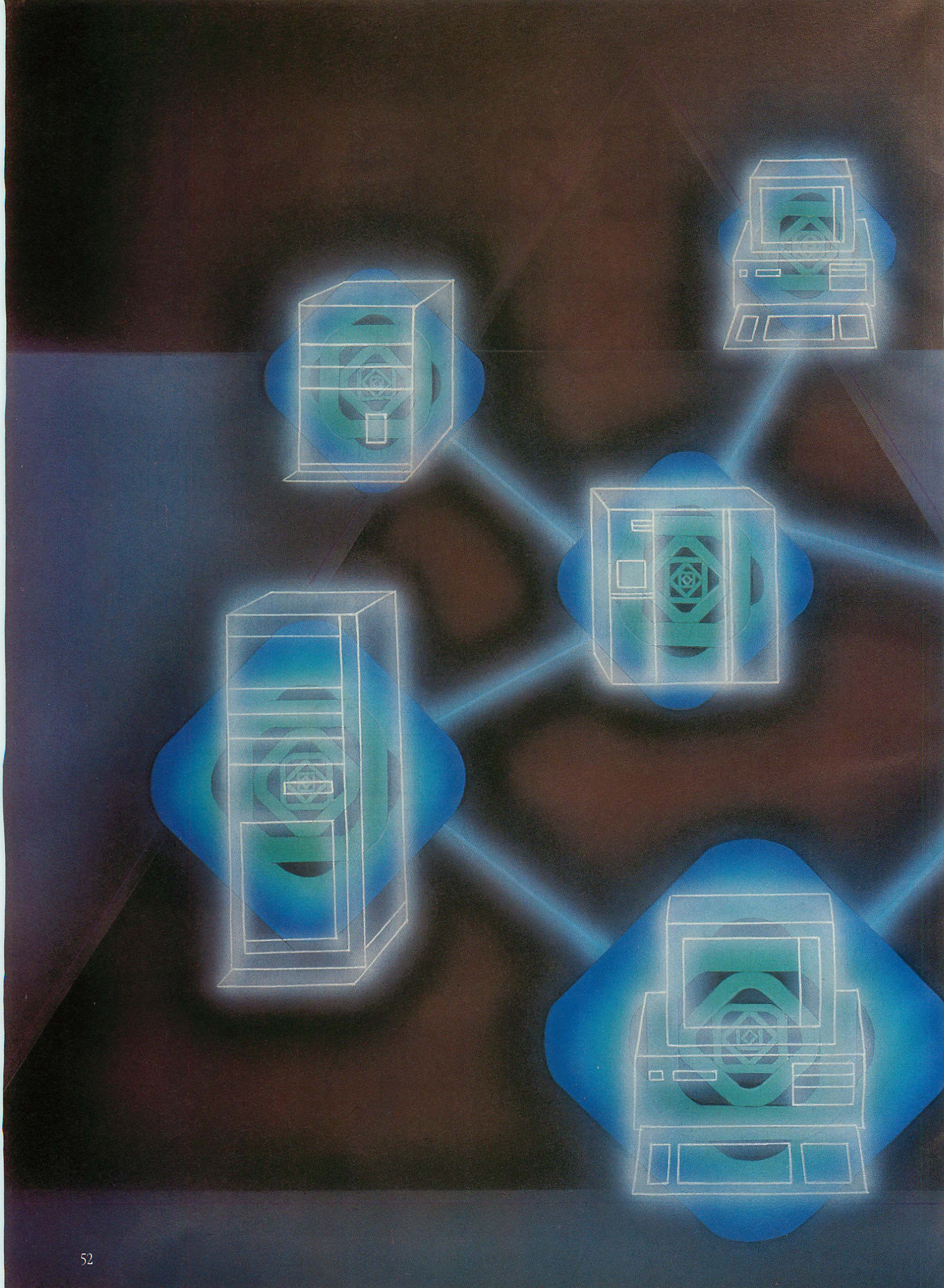

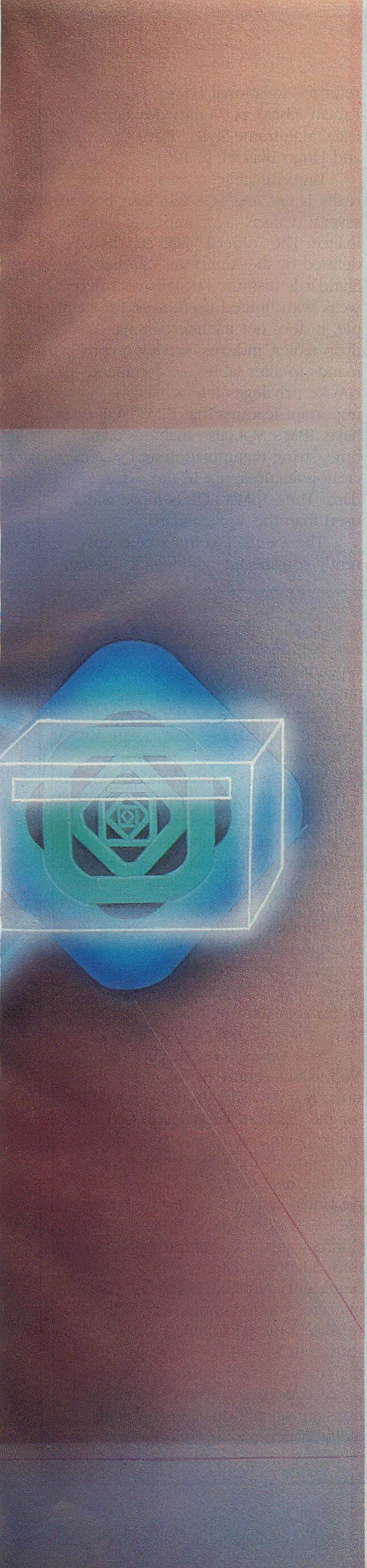

# Lingua Franca for Databases

*This common database language will expedite linking dissimilar machines and databases within and between organizations: toward standardization.*

RICHARD FINKELSTEIN

Standards are as essential in the computer world as a common language, uniform traffic signs, and standard currency are to the sane, organized existence of a nation. Developers of hardware and software are always struggling to establish standards—with limited success. Today there is a striking lack of a standardized language for communication between databases. Yet the need is great; databases are primary repositories of information and standard access is important to link them within a corporation or between corporations. This is important in the PC environment, where database development has been ad hoc and databases from several vendors might be used in one organization.

A potential standard is beginning to emerge for relational databases: Structured Query Language (SQL), developed as a language for the relational model described by mathematician E. F. Codd in the early 1970s, while he was working for IBM's San Jose Research Laboratory. SQL supports query processing transactions, data manager security, integrity, and recovery. Because it is being adopted as a standard database language, SQL plays a key role in connectivity and distributed processing.

**BIRTH OF SQL**

Shortly after Codd published his papers introducing the relational concept of database design (see the sidebar, "What Is Relational?" p. 54), IBM launched a project designed to turn his ideas into a commercially viable data manager. To achieve this goal, IBM needed a nonprocedural language that could perform all relational operations, including selection, projection, join, union, difference, product, division and intersection. Thus, SQL was developed.

ILLUSTRATION • ANDY LEVINE

By the mid-1980s IBM announced two SQL-based relational database management systems for its mid-range and mainframe computers—SQL/DS and DB2. Both of these products are now evolving into the corporate mainframe database standards with a combined installed base of more than 4,000 sites. IBM intends to offer a microcomputer version of DB2 that will be able to run under OS/2.

IBM propelled the emergence of SQL as a standard for relational databases when it announced in May 1987 that it was enhancing its SQL-based data management products to comply with its new System Application Architecture (SAA). Announced in March, SAA is IBM's common framework for strategic application development tools, end-user facilities, and communications architecture designed to facilitate connectivity and distributed processing. IBM also announced that it would use an SQL database management engine, together with a full complement of application development and end-user tools, in OS/2 Extended Edition. With these moves, IBM signaled that the company planned to use SQL as a standard language for future relational database products.

Several well-known SQL implementations are already on the market for minicomputers and PCs, including Relational Technology's INGRES, Oracle Corporation's ORACLE, Informix Software Inc.'s INFORMIX, Gupta Technologies, Inc.'s SQLBase, Software Systems Technology, Inc.'s XDB, and Sybase, Inc.'s SYBASE. Ashton-Tate and Lotus have both announced support for SQL in future products. The PC versions of the two leading mainframe data managers, INGRES and ORACLE, are reviewed following this article (for additional details, refer to "Relational Power, PC Ease," Fabian Pascal, p. 74 and "Managing Data, Mainframe-Style," Dave Browning and Hugo Blasdel, p. 106).

Unfortunately, at present, there really is not one SQL standard. Instead, several dialects are competing for dominance. The "official" SQL standard as defined by the American National Standards Institute (ANSI) is considered weak with limited usefulness; for example, it does not include commands to drop tables, indexes, or views; commands to alter tables; or commands to revoke privileges interactively—important features that IBM's SQL does have. IBM's SQL also includes date, time, string manipulation and system catalog features, not in the ANSI standard. Thus, IBM's SQL is more widely used than the ANSI standard.

The ANSI SQL committee is currently considering additions to its stan-

## WHAT IS RELATIONAL?

In October 1985, mathematician E. F. Codd published a two-part article in *Computerworld*, in which he set forth rules on which relational data managers should be based. His articles were in response to a growing trend by mainframe database vendors to use the relational name without, he thought, fully implementing essential ingredients. Codd's articles were controversial and drew criticism from many vendors who at the time were rated poorly in conformance to Codd's relational database model. If his definition were applied to many of the data managers that run on PCs today and claim to be relational, the results would be similar.

An oft-used one-line definition for relational databases are those that are made up of tables. But this trite definition fails to describe the unique structure and requirements of the tables. Codd came up with one foundation principle and 12 related rules specifying explicit characteristics that a relational system must have. Codd states that a database management system fulfilling at least half of these rules and having the capabilities eventually to fulfill all of them, can be considered relational. Any SQL-based data manager implementing IBM's SQL with a system catalog that can be queried using SQL meets seven of Codd's rules.

Because most micro database products on the market today do not meet half of the rules, they cannot be considered fully relational. A common response from vendors of these products, when confronted by their lack of conformance with Codd's rules, is that they are not concerned with conforming to a model as long as their data managers are practical.

Full adherence to the relational model greatly simplifies application development and maintenance. Engineering and architectural design disciplines have known for hundreds of years that a strong theoretical foundation is desirable. Imagine flying a jet that was designed without any regard to aerodynamics and structural theory.

### SUMMARIZING THE RULES

Codd's rules address the relational model's structure, integrity, data manipulation capabilities and fundamental design of relational databases. Codd's Foundation Rule states that any system claiming to be relational must be able to manage databases entirely through relational capabilities. A user should never be forced to use anything except the relational language itself. If a vendor provides a language interface (COBOL, Pascal, etc.), then there should be no way that the relational integrity rules can be subverted.

Relational data managers should have a system catalog that stores information in tables and can be accessed with the relational language. The relational language must be complete and support all relational operators. Full insert, update, and retrieval functions should exist plus security and transaction processing support.

The relational model requires physical, logical, and distributed data independence. In SQL this is supported by views, optimization, and various relational operators such as UNION. Any view theoretically updatable, should be updatable through relational language. No vendor currently conforms to this rule; it is a major pitfall of relational databases.

All data should be accessible through row name, primary key, and column name. This is the guaranteed access rule. Without primary keys, access to a particular occurrence of data cannot be ensured.

Null values must be supported. Null values represent missing and unknown data. It should be possible for the database language to define integrity constraints and store this information in the system catalog.

Because user complaints about relational systems usually are traceable to vendors not complying with Codd's rules, the multiple benefits of fully relational data managers are not being fully realized. Today, no data manager vendor implements a true relational model fulfilling all Codd's rules, but Sybase comes close. When the rules are fully utilized, true relational databases will save organizations substantial development and maintenance costs.

*—Richard Finkelstein*

dard, including referential integrity, user-defined integrity, and global definition of data types, such as date and time intervals and definitions for embedding SQL in traditional languages such as C, COBOL, FORTRAN, and PL/1. In the meantime, the two SQL dialects share enough in common so that users knowing one will not have difficulty learning the other.

## ATTRIBUTES OF SQL

SQL is nonprocedural and set-oriented in nature; that is, it allows users to specify what is to be done, and it processes data as sets of elements rather than one row (record) at a time as in procedural languages. Nonprocedural languages are more productive than procedural languages and will probably be the dominant mode of application development in the future.

SQL was created to manipulate data in relational data managers. Unlike hierarchical and network systems, relational applications do not need to describe physical storage of data, and relationships do not need to be predefined within the database definition but can be specified whenever they need to be retrieved. In addition, table orientation of relational databases is far easier to understand and manipulate. Unlike other database topologies, relational systems have a strong theoretical foundation based upon relational algebra and first-order predicate logic. This mathematical framework is important because it is the basis for the physical and logical data independence that characterizes fully relational data managers. For more complete information on relational databases, see the article, "Relational Database Design," Dave Browning, July 1987, p. 112.

SQL saves time, is flexible, terse, has only 12 commands, and is already used extensively on mainframes. The language is useful for both end users and programmers. End users can enter SQL statements directly or can use a front-end tool that generates SQL statements. Three types of front-end tools are available: menu-driven interfaces, query-by-example interfaces, and English-language interfaces.

ORACLE has a menu-driven front-end, while INGRES, SYBASE, INFORMIX, and XDB all have query-by-example facilities. Relational Technology recently entered into an agreement with Natural Language, Inc., a company that specializes in developing sophisticated English-like query tools.

All SQL vendors currently offer fourth-generation language (4GL) tools that allow use of SQL in its natural nonprocedural mode. However, SQL can be embedded by programmers into applications written in third-generation languages such as C, COBOL, and FORTRAN.

Systems developers can test SQL commands in an interactive mode and then embed them in application code. Besides being very useful for testing and debugging, SQL is invaluable for prototyping applications. Designers can build database structures, design tables, and verify design completeness without having to write application code. Users can also become involved in the design and verification process very early in the development life cycle. Because programmers and end users will both understand and use SQL, communications between the two groups will be greatly enhanced, leading to improved applications definition.

**FIGURE 1:** *Sample Relational Database*

EMPLOYEE TABLE (EMP)

| E_NO | E_NAME | E_ADDRESS | DEPT_NO | SALARY |
|---|---|---|---|---|
| 200 | D. SLOAN | 100 WABASH S.W. | D01 | 1500 |
| 100 | M. STARR | 50 W. LEVY | D03 | 2300 |
| 400 | R. KRAFT | 2300 CONCOURSE | D01 | 3000 |
| 300 | B. WEINBERG | 1080 CAMDEN DR. | ? | 2000 |

DEPARTMENT TABLE (DEPT)

| DEPT_NO | DEPT_MGR | DEPT_BUDGET |
|---|---|---|
| D02 | L. HIGGINS | 500000 |
| D01 | F. BROWN | 250000 |
| D03 | G. SANDERS | 750000 |

SKILLS TABLE (SKILLS)

| E_NO | SKILL |
|---|---|
| 200 | COBOL |
| 100 | DOS |
| 300 | PASCAL |
| 200 | SQL |
| 200 | BASIC |

Three tables used to demonstrate the power and terseness of SQL commands are Emp, Dept, and Skills. The question mark stands for a null value.

## POWERS OF SQL

SQL has three distinct component parts: data manipulation language (DML), data definition language (DDL), and data control language (DCL), each described in detail below. SQL also includes a system catalog and performance optimizer, both of which are essential to any true relational database system. The catalog and optimizer are necessary in any architecture seeking to connect database systems.

**Data manipulation language.** DML handles functions such as retrieving, inserting, updating, and deleting rows. Consider a personnel database with three tables: Emp, Dept, and Skills. Figure 1 shows structures of these tables. Notice that in the figure Weinberg is not assigned a department. The question mark in the department column (field) by Weinberg's name represents a **null**, which means the value is inapplicable or unknown. Null values are important in allowing relational data managers to select only those rows that have values in a given column and to recognize the missing data.

For manipulating tables, DML uses the commands SELECT, UPDATE, DELETE, and INSERT. The heart of SQL's DML is SELECT, which is used for all retrieval operations and should be able to support all relational operators. SELECT has the general form of:

```
SELECT [DISTINCT] item-list
FROM tables
[WHERE search-conditions]
[GROUP BY columns]
[HAVING expression]
[ORDER BY columns]
```

in which items are selected from rows in the table named, if the specified search conditions are met. Resulting data from tables can be organized using GROUP BY, HAVING, and ORDER BY. GROUP BY rearranges the table

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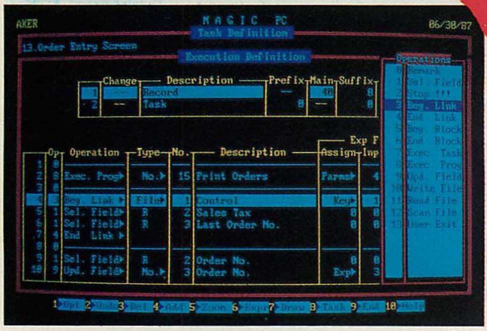

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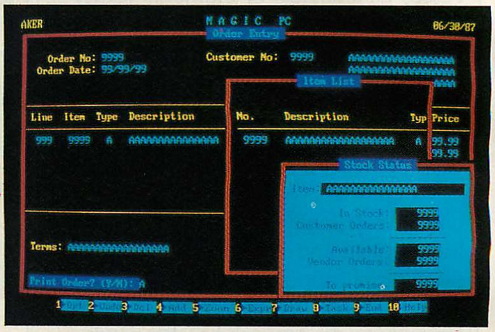

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into groups having the same value in the columns named; HAVING eliminates rows not meeting the expression given; and ORDER BY sorts on the ascending or the descending values of a given column.

The item-list can refer either to a list of specific columns or to all columns (indicated by an asterisk) in a row of a table or view. A request to find all employees (**emp_no** and **emp_name**) in department D01 looks like the following:

```
SELECT e_no, e_name
FROM emp
WHERE dept_no = 'D01'
```

To select all columns from the employee table, the asterisk, would then be employed:

```
SELECT *
FROM emp
WHERE dept_no = 'D01'
```

Duplicate rows can be eliminated with DISTINCT:

```
SELECT DISTINCT (dept_no)
FROM emp
```

The importance of NULL is illustrated by the following SQL statement that returns only those employees who have been assigned to a department:

```
SELECT e_name
FROM emp
WHERE dept_no IS NOT NULL
```

As in any relational table, no implicit ordering of rows is possible. Thus, the employee table can be sorted into name sequence using the ORDER BY clause as follows:

```
SELECT *
FROM emp
ORDER BY e_name
```

SQL can include compound Boolean conditions in the WHERE clause using **and** or logic. The shorthand form for **or** is the IN predicate:

```
SELECT *
FROM emp
WHERE dept_no IN ('D01', 'D02')
```

This query will find all employees who are in departments D01 or D02.

The LIKE clause can be added to the WHERE clause to perform the following pattern searches:

```
SELECT *
FROM emp
WHERE e_name LIKE 'M_ar%'
```

The underscore is a wild card for one position while the % sign can be replaced by any number of characters. In the example that is presented above, SQL will find all of the names that have **M** as the first letter and **ar** as the third and fourth letters.

In addition, SQL's DML has several built-in mathematical functions. They are AVG (average), COUNT, MAX, MIN, and SUM. The following gives an example of their usage:

```
SELECT MAX (budget), MIN (budget),
  AVG (budget)
FROM dept
```

One of the properties of a relational database is that the result of any query is a table. The result of the query below:

```
SELECT e_name, dept_no
FROM emp
```

yields the table in figure 2. It is a logical table rather than a physical one and can be used by SQL in future queries by supporting a nested query structure that permits a higher-level query to use results of a lower-level query. For example, the following nested query can be used to find all employees who have skills listed in the Skills table:

```
SELECT e_name
FROM emp
WHERE e_no IN
      (SELECT e_no
       FROM skills)
```

The SELECT statement within parentheses (called the subquery) retrieves all employee numbers in the skills table. The SELECT in the main query finds all names in the employee table who have numbers that were also in the set of employee numbers retrieved by the subquery SELECT. The following nested query finds all departments that have budgets greater than the average departmental budget:

```
SELECT dept_no
FROM dept
WHERE budget >
      (SELECT AVG (budget)
       FROM dept)
```

A more advanced form of this type of query is the nested correlated query, in which the lower-level query refers to some value in the higher-level query. It could be used, for example, to find all employees whose salaries are greatest in their departments. A simple nested query is not sufficient in this case because the average that has to be calculated is for the department and not for the whole company. Typically, a programmer first needs to calculate the average salary for each department, store the results, and compare each employee with his/her department average. In SQL the query would be:

```
SELECT e_name, salary
FROM emp a
WHERE salary >
      (SELECT AVG(salary)
       FROM emp b
       WHERE a.dept_no = b.dept_no)
```

In this query, SQL uses table aliases; SQL constructs two logical tables, a and b, which represent the physical table **emp**. The nested query calculates the average for the employee's department, which is then compared to the employee's salary. See C.J. Date's book *A Guide to DB2* (Addison-Wesley, 1985).

SQL's GROUP BY command creates logical groupings of rows, which can be acted upon by the HAVING predicate. The SQL command:

```
SELECT *
FROM skills
GROUP BY e_no
```

**FIGURE 2:** *Sample Result*

| E_NAME | DEPT_NO |
|---|---|
| D. SLOAN | D01 |
| M. STARR | D03 |
| R. KRAFT | D01 |
| B. WEINBERG | ? |

The result of every SQL query is a table, the result of the query: SELECT e_name, dept_no FROM emp.

**FIGURE 3:** *GROUP BY*

| E_NO | SKILL |
|---|---|
| 100 | DOS |
| 200 | COBOL |
| 200 | BASIC |
| 200 | SQL |
| 300 | PASCAL |

GROUP BY logically groups rows. Using GROUP BY e_no on the Skills table produces three tables, one for each employee number.

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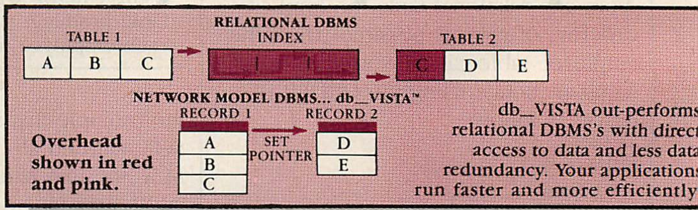


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forms three groupings as pictured in figure 3. The following SQL command finds all employees that have more than one skill:

```
SELECT e_no
FROM skills
GROUP BY e_no
HAVING COUNT(*) > 1
```

The result of this query would yield only employee 200, because that is the only grouping that has a count of rows greater than one.

SQL can join two tables using the SELECT command:

```
SELECT e_name, skill
FROM emp, skills
WHERE emp.e_no = skills.e_no
```

In this example, table names are used to qualify **e_no**, because **e_no** appears in both tables. The result of this query is a list of all employees and their skills. Theoretically, there is no limit to the number of tables that can be joined. The following query joins three of the tables:

```
SELECT e_name, skill, dept_mgr
FROM emp, skills, dept
WHERE emp.e_no = skills.e_no and
  emp.dept_no = dept.dept_no
```

In addition, the results of two queries can be merged using the UNION command:

```
SELECT e_name
FROM emp
WHERE salary > 2000
UNION
SELECT e_name
FROM emp
WHERE salary >
    (SELECT AVG(SALARY)
     FROM emp)
```

This query merges the names of all employees who are currently making more than $2,000 with the names of all of the employees who are earning salaries that are higher than the average employee salary.

EXISTS is used to check if a subquery returns at least one row. For example, the following query determines whether any employee has more than three skills:

```
SELECT e_no
FROM skills
WHERE EXISTS
      (SELECT e_no, count(*)
       FROM skills
       GROUP BY e_no
       HAVING count(*) > 3)
```

If at least one employee ends up being selected, then the main query is executed and the **e_no** having three skills is returned.

In addition, SQL includes statements for updates, deletes, and inserts. All statements follow the same general syntax. For example, to increase all employee salaries by 10 percent:

```
UPDATE emp
SET salary = salary * 1.10
```

To delete all employees from the department D10:

```
DELETE
FROM emp
WHERE department = 'D10'
```

*A logical unit of work is a group of statements that must be executed together to prevent partial updating of the database.*

To insert rows from another table using the nested selects from within an INSERT command:

```
INSERT
INTO emp
      (SELECT *
       FROM emp_temp
       WHERE dept_no = 'D10')
```

Finally, SQL's DML includes COMMIT and ROLLBACK commands for transaction management. A logical unit of work (LUW) is a group of statements that must all be executed together to prevent only partial updating of the database. A BEGIN command explicitly starts an LUW in some relational data managers, while an implicit BEGIN command starts an LUW in other relational systems. COMMIT ends an LUW and physically updates the database. Because partial updates can occur in single-user as well as multiuser systems, a good data manager will implement automatic transaction management in both single-user and multiuser versions of its program.

If a transaction terminates before a COMMIT or if a database manager, program, or end user issues a ROLLBACK, all updates that were made since the beginning of the LUW will be automatically canceled, thus returning the database to its state prior to the beginning of the transaction. This is important to preserve integrity of the database. For example, an invoice would not be applied to the invoice table unless all associated detail lines have been inserted into the detail-line table. If the transaction does not complete, then all partial updates (detail lines, invoice row, and index rows) are automatically canceled and the database restored to its previous state. End users can invoke COMMIT and ROLLBACK in SQL to roll back UPDATE, INSERT, and DELETE. SQL backout logic is automatic and requires no programming.

**Data definition language.** The SQL DDL creates tables, indexes, and views. The following query creates the employee table in figure 1:

```
CREATE TABLE emp
  (e_no smallint NOT NULL,
  e_name char(20),
  e_address varchar (40),
  dept_no char(3),
  salary integer)
```

SQL supports various types of data formats including small integers, integers, characters, variable characters (1-254 characters), long variable characters (up to 32,000 characters) and float. Other types of data formats that vary with implementation may include date, time, and graphics. **Not null** indicates that the employee number must have a value for all rows inserted.

An index on the employee number will guarantee unique values:

```
CREATE UNIQUE INDEX on emp (e_no)
```

The combination of the unique index and **not null** specification forms the primary key of a table.

IBM's SQL has only limited capabilities for altering table definitions. The user can only add new columns:

```
ALTER emp Add emp_spouse char(20)
```

However, most SQL implementations allow modification and deletion of columns. With IBM's products, the user creates a new table and uses an INSERT with nested SELECT to move old rows into a new table definition.

Views are an important concept of the relational database model and are defined by a standard SELECT:

```
CREATE VIEW emp_D10
AS (SELECT *
    FROM emp
    WHERE dept_no = 'D10')
```

A user can access the view **emp_D10** just like any other table:

```
SELECT *
FROM emp_D10
```

In this case, only employees in department D10 will be returned, because

**FIGURE 4:** ***Sample System Catalog***

**SYSTEM. SYSTABLES**

| TABLE_NAME | CREATOR | DATE_CREATED | COMMENTS |
|---|---|---|---|
| EMP | USER1 | 10/18/86 | EMPLOYEE TABLE |
| DEPT | USER2 | 9/14/86 | DEPARTMENTS |
| SKILLS | USER1 | 7/29/86 | SKILLS TABLE |

**SYSTEM. SYSCOLUMNS**

| COLUMN_NAME | TABLE_NAME | MAX_VALUE | MIN_VALUE |
|---|---|---|---|
| EMP_NO | EMP | 3874 | 0032 |
| EMP_SALARY | EMP | 500 | 10000 |
| DEPT_NO | EMP | D01 | D20 |
| DEPT_NO | DEPT | D01 | D30 |

**SYSTEM. SYSINDEXES**

| TABLE_NAME | COLUMN NAME | UNIQUE |
|---|---|---|
| EMP | EMP_NO | YES |
| EMP | DEPT_NO | NO |
| DEPT | DEPT_NO | YES |
| SKILLS | EMP_NO, SKILL | NO |

System tables contain definitions of objects (table names, column names, indexes, etc.). These can be queried by users with SQL data manipulation language.

the view is defined only for department D10. View definitions are stored in the system catalog and are not permanently defined physical tables. They are extremely useful for furthering data independence, for hiding joined tables from users, and for enhancing security.

**Data control language.** Security is the major concern of DCL, which revolves around the GRANT and REVOKE commands. Users are granted privileges (SELECT, INSERT, UPDATE, DELETE) on tables or views. A user can be limited to retrievals on the employee table:

```
GRANT SELECT ON emp TO user1
```

Another user can have retrieval and update privileges:

```
GRANT SELECT, UPDATE ON emp to user2
```

All users can be granted the right to insert new rows:

```
GRANT INSERT ON emp to PUBLIC
```

The database administrator has the ability to remove a privilege:

```
REVOKE SELECT, INSERT ON emp from
  user1
```

Privileges can be revoked from base tables (physical tables) or views. Using views, an administrator can assign a user the right to retrieve only certain specified information:

```
GRANT SELECT ON emp_D10 to user3
```

IBM's SQL supports the WITH CHECK OPTION, which verifies that updates and inserts do not violate the view definition:

```
GRANT UPDATE ON emp_D10
WITH CHECK OPTION
```

With the CHECK OPTION, user3 is prevented from retrieving information about employees who are not in department D10.

**SQL system catalog.** Codd's definition of relational databases explicitly states that a system catalog is mandatory. The catalog serves several purposes. It contains definitions of objects (table names, indexes, views, column names, etc.) created by the DDL. These definitions are stored in tables, just like any other SQL table. Typically, the system catalog contains these definition tables, as in figure 4. Information and names vary from implementation to implementation. Because ANSI gives no direction on this subject, most vendors follow, to some degree, the catalog structure used by IBM.

A database administrator, application developer or end user can query the catalog and find information. For example, an end user can find all of the column names pertaining to a particular table, or a database administrator can find all of the tables that contain a particular column name:

```
SELECT table_name
FROM system.syscolumns
WHERE column_name = 'dept_no'
```

Some systems such as INGRES and SYBASE store application logic in the system catalog. A programmer can find all programs that access a particular table:

```
SELECT program_name
FROM system.applcode
WHERE command_line LIKE '%emp%'
```

In this command, SQL is used to search a table called Applcode, which contains all the SQL commands. The LIKE command performs a pattern match looking for the table named **emp** and returns the program name back to the programmer.

More fundamentally, the system catalog is used by the data manager itself. For example, all security information contained in GRANT commands is stored in the catalog. Every time a user logs into the database, the data manager queries the system security table and checks whether the user has authorization to access the database as well as the tables within it.

The system catalog also is essential in distributed databases, where it lets the data manager know which remote computer contains certain data so that the data manager can retrieve the data transparently to the user. The system catalog also is important in optimizing query performance.

**Optimization.** Every SQL system includes a specialized program, called the optimizer. The optimizer maximizes performance of the system transparently to the user during retrievals and updates. Optimization has some of the aspects of artificial intelligence (AI) inherent in it. However, the optimizer is more appropriately given the name, "smart" program.

SQL supplies no direct way for a user to reference an index because a basic rule of relational databases is that program logic should be independent of physical structure. If an optimizer determines that operations would be

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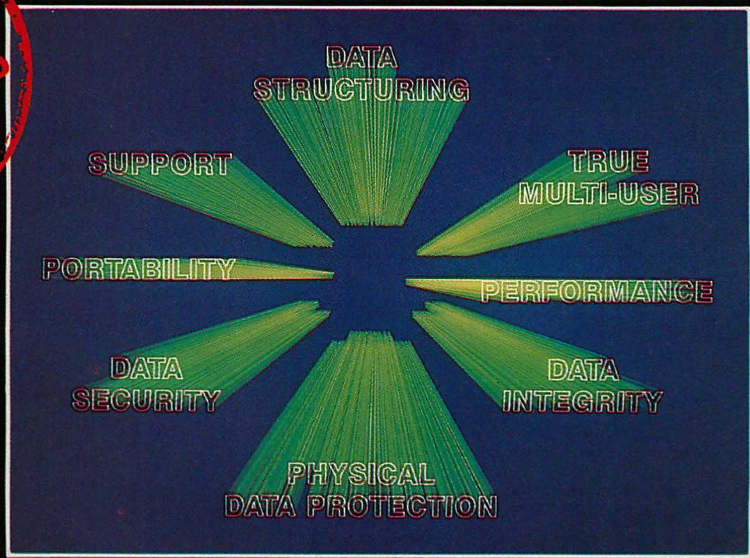


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faster using an index, then it automatically uses it. If no indexes exist, the optimizer determines the best strategy to retrieve or update the data. The optimizer can determine which indexes are available and other statistics about the data (for example, how many rows exist in the table) by making a query of the system catalog.

The optimizer allows a program to react automatically to changes. Suppose a table is initially quite small—perhaps 100 rows; the optimizer might decide that reading the table directly would be faster than using an index. A few months later the table grows to 10,000 rows and the optimizer, recognizing the substantial growth, automatically uses indexes. A system developer can add an index at any time, and the optimizer starts using it without the developer being obliged to change any application code.

Optimizers vary in sophistication from one SQL system to another. In fact, this is a great source of competition between vendors. Usually indexes will be used for direct accesses, ORDER BY, built-in functions (SUM, AVG, COUNT, etc.), LIKE, and EXISTS. Their use with built-in functions is especially interesting: the data manager can calculate totals and averages or counts without ever accessing the base tables because all information can be retrieved directly from the index.

## SOLVING DATA SHARING

The aim of database sharing is economical and timely sharing of information and resources. It can occur on one multiuser system, on closely coupled systems such as on Digital Equipment Corporation's DEC clusters, or between remote computers linked via local area networks (LANs), wide-area networks (WANs), mainframe-micro links, or distributed database architectures.

In any of these systems, the characteristics of SQL make the language ideal for solving many problems that occur in database sharing. Developers of multiuser systems are faced with basic problems of data security, integrity, and recovery. As already mentioned, SQL includes GRANT and REVOKE commands that support database security and COMMIT and ROLLBACK commands for transaction management to help ensure the integrity of the database.

In addition, all SQL-based data managers include a recovery manager that works in conjunction with COMMIT and ROLLBACK to provide database recovery in the event of a system failure. When a system fails, a transaction log containing a history of all completed transactions is essential. When the database is restarted, the data manager reads this log file and restores the database to its most current state, without any loss of "committed" transactions. Any uncommitted transactions should be automatically backed out by the data recovery manager. A good data manager should require negligible operator intervention.

Another important aspect of database integrity is record locking. Locking prevents simultaneous update of a single record by two or more different programs. This ensures that one program does not destroy the update of

> *Optimizers are a great source of competition between data management vendors, as they vary in sophistication.*

another program. Record locking is complex, because many programs can be working on the same records at the same time. The database locking manager seeks to provide data integrity and at the same time promote high transaction throughput. The better designed a locking manager is, the faster a data manager can process data. SYBASE has advanced locking manager logic as does SQLBase. All SQL systems support automatic record locking so that programmers do not have the additional task of programming the logic.

Locking managers should automatically handle deadlock, a problem that occurs when two programs are simultaneously waiting for each other to terminate. Both programs are held in wait states indefinitely. The locking manager detects this situation, selects one of the programs for termination, and sends a message to the program stating that the transaction was terminated because of this deadlock.

Some data managers currently on the market implement a nonlocking type of concurrency control mechanism. These systems allow any application to read a record while the data manager checks for changes during the update process. If the record has been changed by another program in the interval of time that the user initially reads it and the actual update, the update is rejected with a message to the operator.

This, however, presents a host of new problems; users might be making decisions based on information that already has been changed by someone else on the system. For example, an order-entry clerk might be taking an order for a part that already has been sold by another clerk. Most SQL-based data managers implement locking mechanisms that avoid these problems.

## PROMOTING CONNECTIVITY

While SQL is relationally complete and supports security, integrity, and recovery, its most important contribution as a standard will be to connectivity. Vendors of data managers can use SQL to build gateways to access other SQL data managers because they speak the same language and understand one another.

SQL as a standard ensures longevity of applications. For example, if an organization develops a system using an SQL-based data manager from vendor A and vendor B later releases a new SQL engine that supports specialized processing on a network, then vendor A can build a gateway to vendor B's data manager, allowing applications to run unchanged and access the new data manager as if it were the old data manager.

In addition, the SQL standard is roughly analogous to IBM's NETBIOS standard for networking software; it allows vendors to connect through a standard interface. Most data management vendors are now using SQL as a standard to advance connectivity in data management, such as developing database servers for LANs, micro-mainframe links using IBM's Advanced-Program-to-Program-Communication (APPC), and distributed databases. Users who are already familiar with SQL will be in a good field position to take full advantage of this technology as and when it becomes available.

**Servers.** One common technique of data sharing is to have several PCs, connected on a LAN that accesses one computer designated the file-server; each PC runs its own copy of the data manager. The file server is basically a "dumb" repository for files and does not have any data management responsibilities. This configuration is relatively easy for a vendor to implement but presents many problems. No centralized control is possible because the recovery manager, transaction manager, and locking manager are dispersed among all PCs on the network. System

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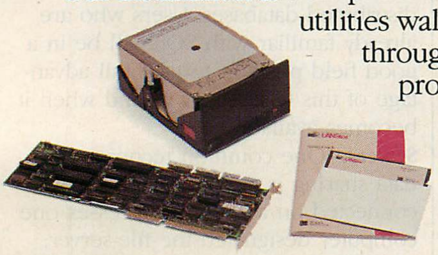

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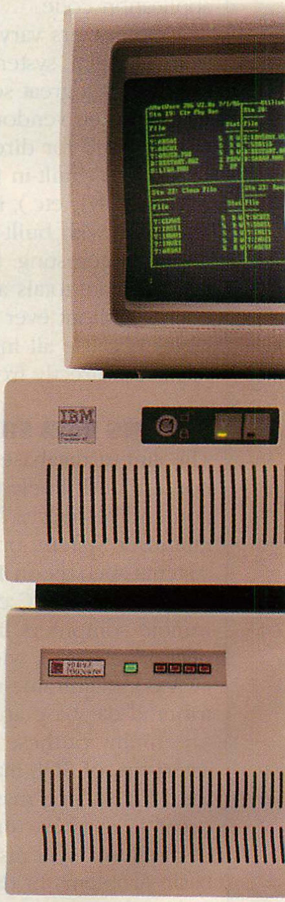

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security and integrity therefore cannot be assured. In order to address these problems, vendors have come up with alternative multiuser approaches.

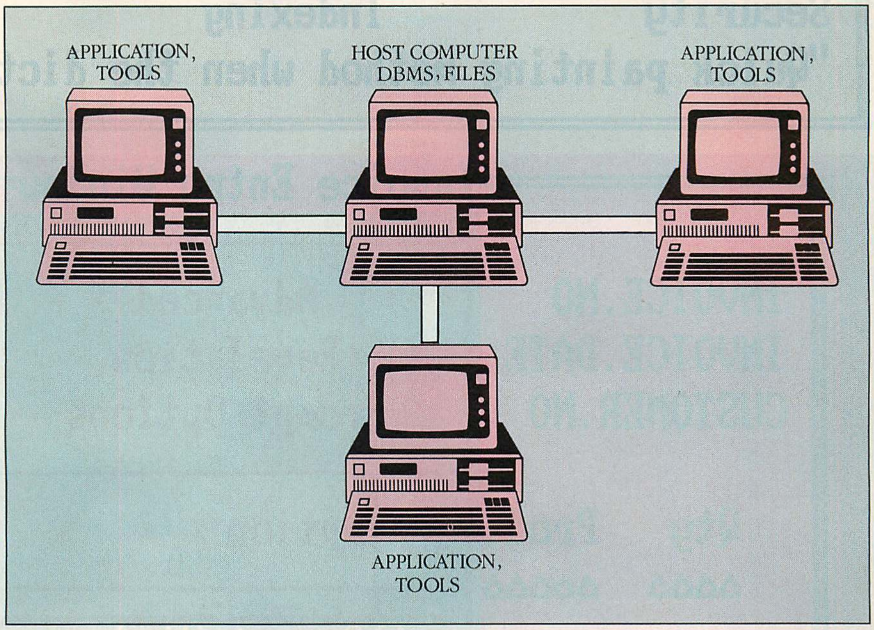
One useful alternative is to connect several PCs to a multiuser host computer using asynchronous lines and terminal emulation programs. In this mode the PC acts as a "dumb" terminal and relies on the host to handle the full work load. While this approach does not utilize a PC's "intelligence," it does centralize all transaction control and system recovery in the host computer instead of dispersed among PCs. Multiple transactions can run simultaneously, each directing their SQL request to the data manager on the host. The data manager takes responsibility for all locking, security, and management of the LUW. These operations are completely transparent to programmers and end users, except for the performance degradation that can result when the host is overtaxed.

The most promising approach emerging on LANs uses database servers to take full advantage of PC power. Applications and tools actually run on PCs, but all database requests are handled by the database server (figure 5), which has all advantages of multiuser computers: centralized security, transaction management, and recovery security systems. The database server also uses the PC intellect; the application logic can be off-loaded from the central computer and executed on PCs. It improves overall performance and allows the database server to concentrate on the database requests received, thereby improving the throughput.

The database-server configuration also helps reduce transmission load and network costs. In a traditional file-server system, all records in a database first must be sent to local workstations where records are selected and processed. In a database-server environment, all selection is performed by the database server, which sends only those records that the application needs. This greatly reduces application processing time and network traffic overhead, especially when a database contains several thousand records. In most implementations, workstations execute applications and SQL tools, such as user interfaces and 4GL, again using the power of the PC and saving the server CPU time.

Many relational database vendors have database servers. Informix has the following server systems available: a classic file-server system with a DOS-based PC storing database files and PC

**FIGURE 5:** ***Sample Server System***




**Most vendors try to reduce network traffic by having workstations run applications and relational data manager tools, while the database server is responsible for running the relational data manager and storing files.**

workstations running INFORMIX and applications; a database-server system with a minicomputer running INFORMIX under VMS while PC workstations run tools and applications under DOS; and several specific systems supporting the Sun workstation, the Apollo workstation, and the AT&T computers.

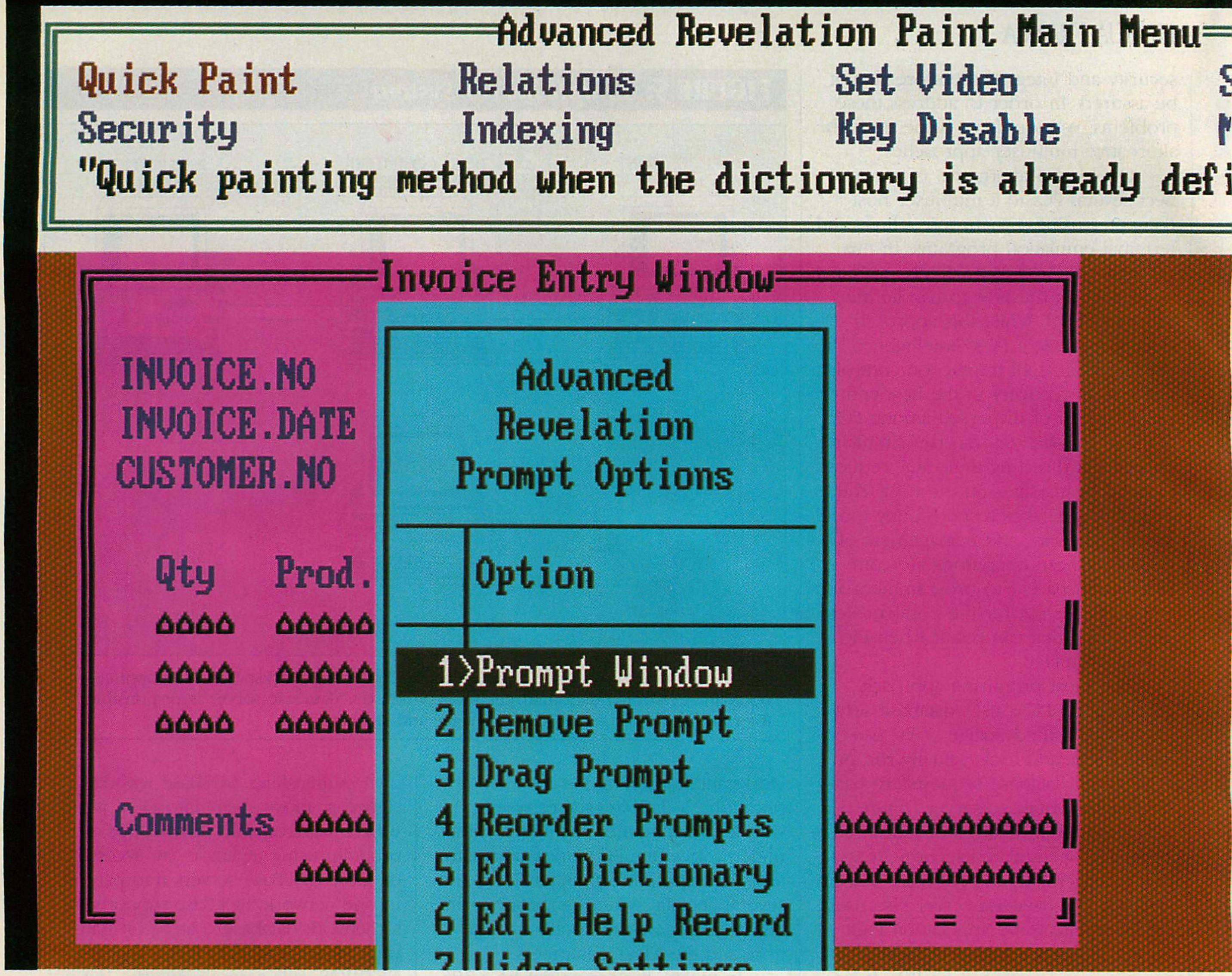
In INGRES, the server can be a 386 (running UNIX), a mini, or mainframe, while in ORACLE, the server can be an 80286- or 80386-based PC (running XENIX), a mini, or mainframe. Multiple servers can be linked, but applications or interactive users on workstations must specify the location of tables needed for a query; SQL statements and data are transmitted by communications packages (INGRES/NET or Oracle Corporation's SQL*Net). INGRES transmits over asynchronous lines; Oracle Corporation plans support for terminal control protocol/internet protocol (TCP/IP) in the near future. In these systems, the server must run a multitasking operating system—both products will run under OS/2 and allow an AT-level computer to act as server.

Gupta Technologies, Inc. has successfully implemented an SQL database server that operates on any LAN that supports NETBIOS (for example, Novell NetWare and IBM Token-Ring Network). The database server called SQLBase can reside on an 80286- or 80386-based PC and does not require a multitasking operating system because it can do its own multitasking. SQLBase was designed to move easily into OS/2 when it becomes available. At this time, a program using SQLBase can access one or more SQLBase servers transparently in one network. SQLBase supports internetwork database sharing on Banyan's VINES network, which supports NETBIOS calls across networks, but not on Novell networks, which do not support internetwork NETBIOS.

Software Systems Technology, Inc. has just released a new database-server version of XDB for beta testing. The server can be any 80286- or 80386-based PC running under DOS. The data files and SQL engine, which is based on a multithreaded architecture and has its own facilities for concurrency control, record locking, and integrity, reside on the server. PC workstations run applications and tools and communicate to the server over any NETBIOS-compatible network.

An SQL database-server technology developed by Sybase, Inc., currently runs on SUN and DEC networks and should eventually be available on PCs. The company incorporates an advanced locking and recovery manager as well as state-of-the-art application and tools for the end user.

**Micro-mainframe links.** Several vendors are now offering links between mainframe SQL databases and PCs. The first such vendor is Micro Decisionware, Inc., with its PC/SQL-link product. PC/

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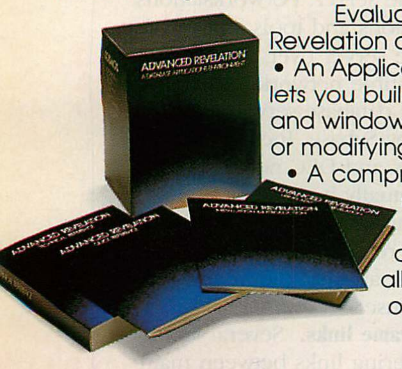


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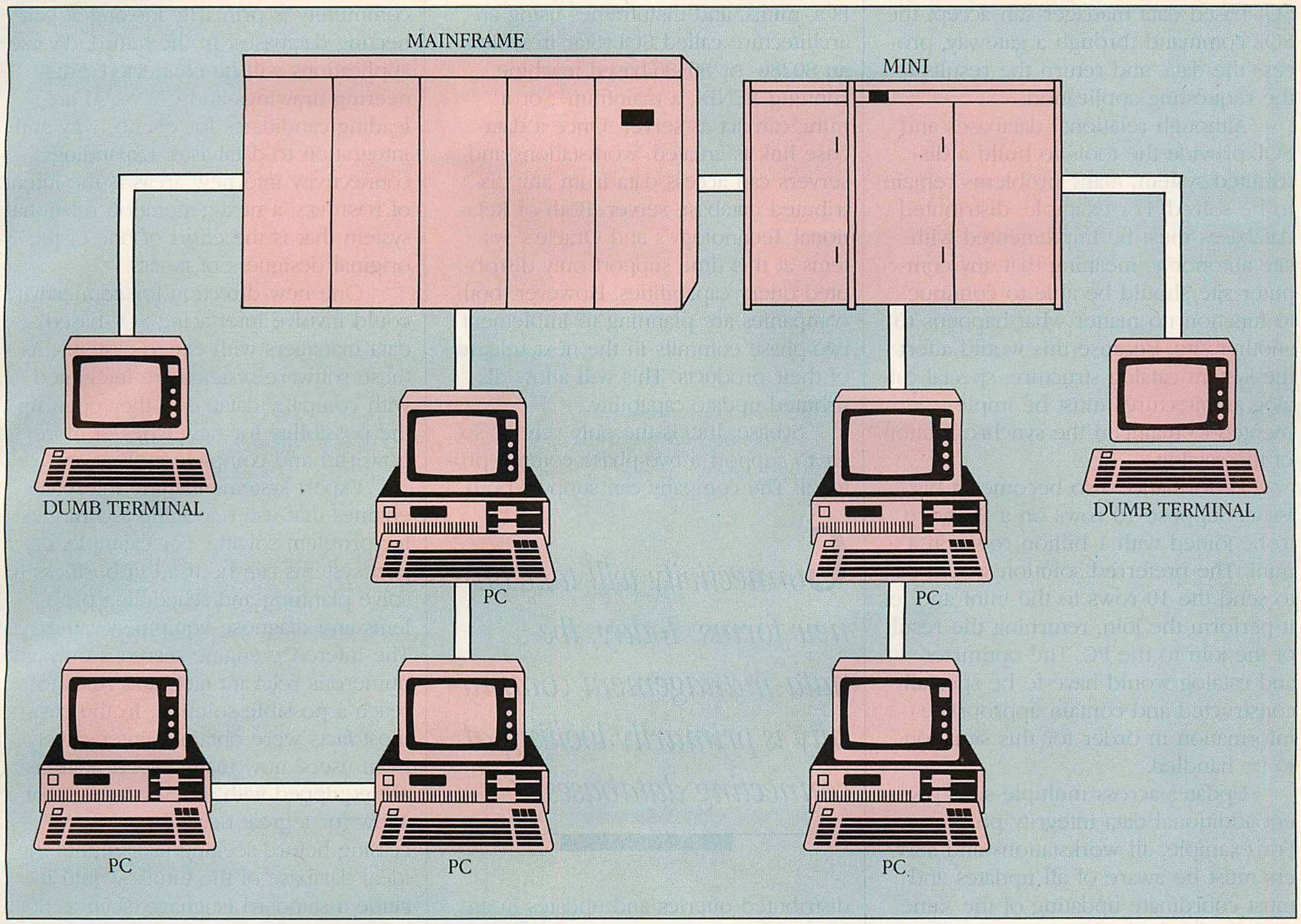
**FIGURE 6:** ***Sample Distributed Database***




**A heterogeneous distributed database is the goal of all relational data management vendors. In this system, any number of servers from different vendors can store files that can be transparently accessed by any other server or workstation.**

SQL-link maintains a copy of the mainframe data manager catalog on the PC. It prompts the user with a series of questions and builds an SQL query that is sent to the mainframe SQL-based data manager. Information is then extracted and downloaded to the PC. Among software currently supported by PC/SQL-link are IBM's DB2 and SQL/DS, Teradata, Britton-Lee, and ORACLE.

Lotus also has a micro-mainframe link called The Application Connection (T-A-C). Lotus has recently entered into an agreement with IBM to develop an interface between 1-2-3/M (Lotus's mainframe version of 1-2-3) and DB2. Lotus also intends to develop and market SQL-based products on the micro, which are likely to be similar to those on its mainframe products. T-A-C will connect all of these products.

Gateways to other SQL-based data managers are now being offered by Gupta. One recently announced gateway connects an SQLBase workstation to IBM's DB2 using APPC. This gateway allows a workstation to use DB2 as a database server, just like any other server on the network. Gupta intends to continue developing gateways that will allow SQLBase programs to access any other SQL-based data manager simply by issuing an SQL command. Oracle's SQL*Connect is designed to provide access to DB2 and SQL/DS; Relational Technology recently introduced a Gateway line of products that currently allows INGRES to access RMS files on a VAX and dBaseIII files on a PC and treat them as INGRES tables; similar gateways for DB2, SQL/DS, IMS, and others are planned. All of the above-mentioned products clearly demonstrate the benefits of the SQL standard—to the user and to the vendor—in promoting connectivity.

**Distributed databases.** Linking multiple servers with PC workstations is an excellent concept, but it has one drawback for workstation users, who must request data from a specific server. The ultimate form of connectivity would allow databases to be distributed across many different computers and yet appear to a program or end user as if it were on one computer (see figure 6 for an example of this).

Relational databases and SQL support this distributed database concept nicely. Because data are addressable by value and not by pointers or physical positions, they can be placed anywhere on a distributed network without affecting the SQL command. Unions permit data from different tables to be merged into one logical table. Joins, on the other hand, permit two or more tables to be combined, regardless of their physical location.

The relational data manager (or perhaps a distributed database manager) can find out where data are by querying the system catalog. The optimizer automatically takes care of performance decisions, independent of where data are located. Views can transparently present users with information regardless of the number of tables associated with the view or where tables are situated. Communications within a heterogeneous environ-

ment would be possible because all database calls are SQL commands. Any SQL-based data manager can accept the SQL command through a gateway, process the data, and return the results to the requesting application.

Although relational databases and SQL provide the tools to build a distributed system, many problems remain to be solved. For example, distributed databases must be implemented with site autonomy, meaning that any computer site should be able to continue to function no matter what happens to another site. Because this would affect the system catalog structure, special catalog architectures must be implemented to maintain the synchronization of the catalog.

Performance also becomes a big issue. Suppose 10 rows on a PC were to be joined with 1 billion rows on a mini. The preferred solution would be to send the 10 rows to the mini and let it perform the join, returning the result of the join to the PC. The optimizer and catalog would have to be specially constructed and contain appropriate information in order for this situation to be handled.

Updates across multiple sites present additional data integrity problems. For example, all workstations and servers must be aware of all updates and must coordinate updating of the same record. For these reasons, two-phase commits are essential when updating tables that are distributed on multiple computers. Basically, a two-phase commit is a two-step process in which all of the computers first signal their intention to commit; this step is then followed by the actual commit.

All these issues are now being explored by major relational data manager vendors. Relational Technology, Inc. offers the most advanced distributed relational data manager available on the market today. It features INGRES/STAR, which basically functions as a distributed database manager and query optimizer, primarily responsible for managing transparent access of data from various servers in the network and optimizing the query solution.

Once set up by the DBA, this system can include a variety of computers, mainframes, minis, and micros, running a variety of operating systems, all connected by INGRES/NET.

Until OS/2 becomes available, only 80386-based PCs running UNIX can act as servers using INGRES/NET. Other PCs can transparently access data from any server but can only participate in the distributed database as workstations.

Oracle Corporation is continuing to develop a distributed database for PCs, minis, and mainframes using an architecture called SQL*Star in which an 80286- or 80386-based machine, running XENIX, a mainframe, or a mini, can act as server. Once a database link is created, workstations and servers can access data from any distributed database server. Both of Relational Technology's and Oracle's systems at this time support only distributed query capabilities. However, both companies are planning to implement two-phase commits in the next release of their products. This will allow distributed update capability.

Sybase, Inc. is the only vendor so far to support a two-phase commit protocol. The company can support both

*Connectivity will take on new forms. Today, the data-management community is primarily looking at connecting databases.*

distributed queries and updates in an homogeneous environment. Problems are still present when implementing distributed databases in a heterogeneous network. This type of distribution is extremely difficult because of the problems of different optimizers and catalog structures as well as dissimilar SQL implementations.

SAA provides a framework for IBM to begin developing distributed database processing. It includes SQL, a standard catalog structure, optimizer, and programmer and end-user interfaces. Relational Technology, Inc., Sybase, Inc., and Gupta Technologies, Inc., should provide significant competition for IBM, in part because of their leads in introducing the distributed database products.

**FUTURE TRENDS**

Relational databases and SQL have opened the door to connectivity—and ultimately to distributed databases. With IBM's formal endorsement of SQL and database-server technology, the industry should see a rapid expansion in multiuser systems and LANs. Distributed database technology will go through a period of maturation and become more practical.

Connectivity will take on new forms. Today, the data-management community is primarily looking at connecting databases. In the future, diverse applications will be connected. Engineering drawings and CAD/CAM are leading candidates for connectivity and integration to databases. Expanding connectivity into new areas is the intent of POSTGRES, a next-generation relational system that is the effort of one of the original designers of INGRES.

One new direction for connectivity could involve interfacing SQL-based data managers with expert systems. As these software systems are integrated with company databases, they open up the possibility for new types of more powerful and complex applications.

Expert systems include inference engines that use reasoning techniques for problem solving. For example, expert systems can be used in business to solve planning and scheduling problems and diagnose equipment failures. The inference engine searches through numerous relevant facts and rules to reach a possible solution. In the past, most facts were obtained interactively from users; now many expert systems are equipped with fact "libraries" that allow for a great deal of query processing before seeking user input. The ideal database of the future would include a standard language, such as SQL, to allow all software, including expert systems, CAD/CAM, and interactive query interfaces, to access data from a central source.

Data managers are on the frontier of a new age of information technology. A good understanding of relational databases and SQL will enable developers, programmers, and end users to use this technology to their advantage.

**SUGGESTED READING**

*Database: A Primer*, C.J. Date, Addison-Wesley, 1984.

*An Introduction to Database Systems*, Vols. I and II., C.J. Date, Addison-Wesley, 1985.

*A Guide to DB2*, C.J. Date, Addison-Wesley, 1985

*A Guide to the SQL Standard*, C.J. Date, Addison-Wesley, 1987.

*A Guide to INGRES*, C.J. Date, Addison-Wesley, 1987.

*Using SQL on the PC*, Richard Finkelstein, Sams Publishing, (Upcoming).

*Richard Finkelstein is a vice president of Codd and Date Consulting Group and publisher of* SQL Review, *a quarterly covering the SQL industry.*

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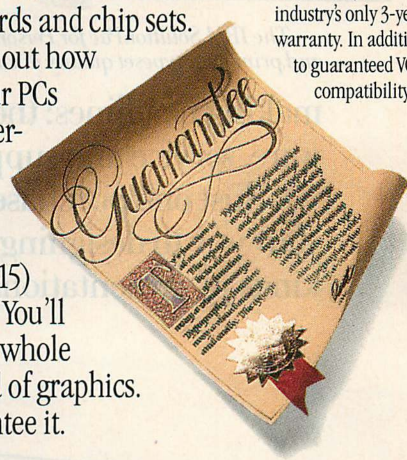


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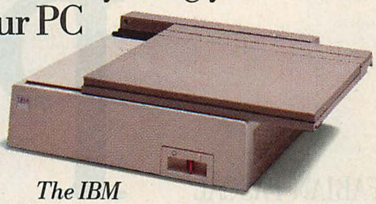

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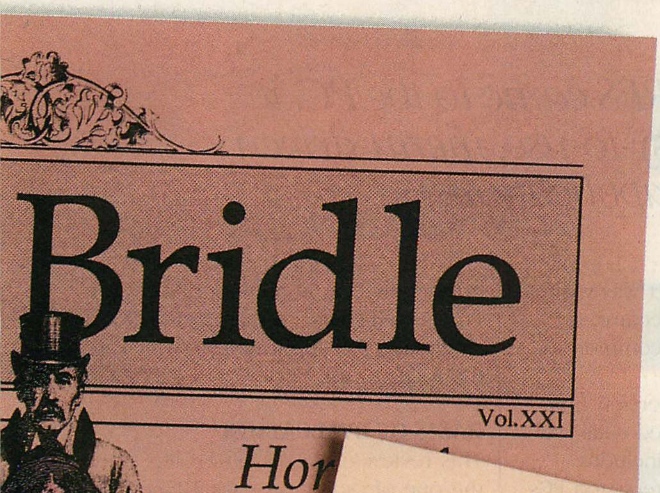
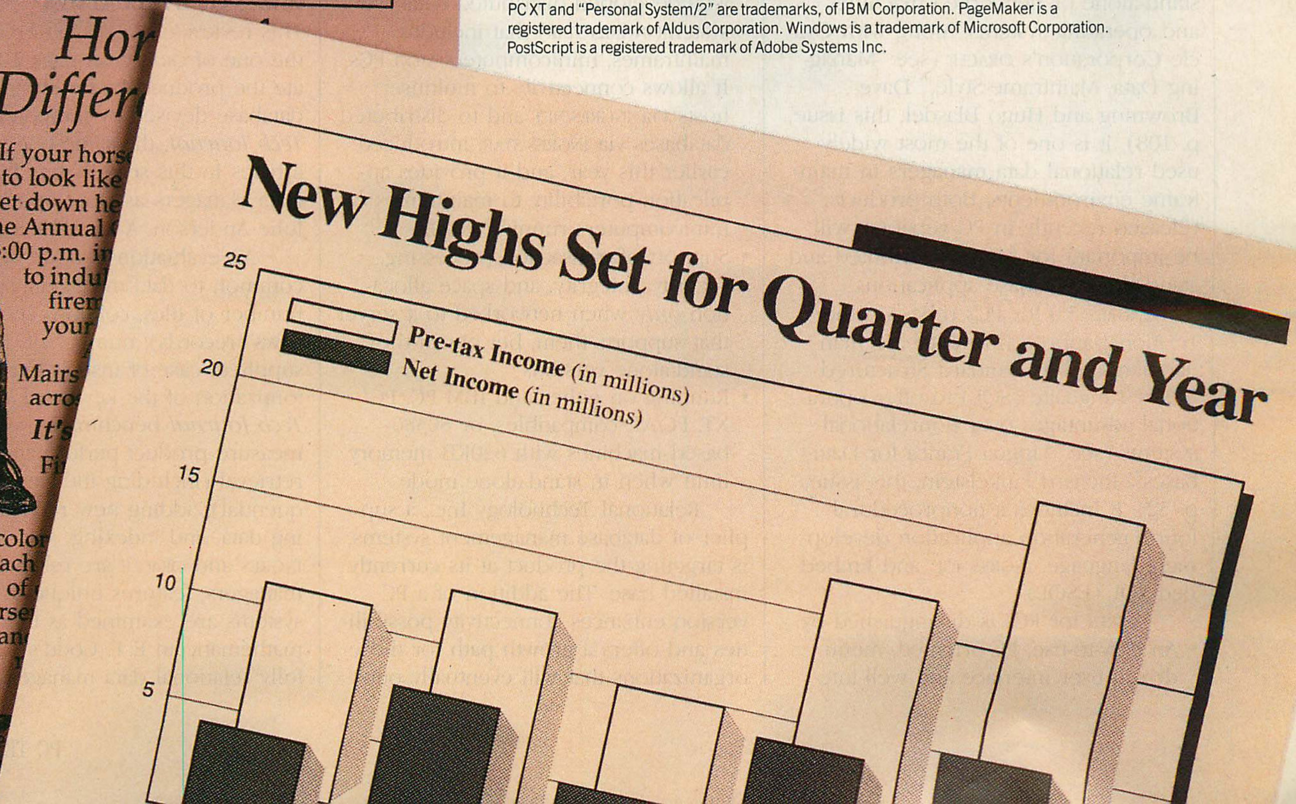


# Relational Power, PC Ease

FABIAN PASCAL

*When mainframe INGRES came to the PC, it quickly adapted the easy-to-use, menu-driven interface typical of PC applications.*

INGRES, from Relational Technology, Inc., is one of a new generation of data managers that attempts to provide one data management solution for different users across a variety of stand-alone or networked machines and operating systems. Along with Oracle Corporation's ORACLE (see "Managing Data, Mainframe-Style," Dave Browning and Hugo Blasdel, this issue, p. 108), it is one of the most widely used relational data managers in mainframe environments. Both products, released recently in PC versions, will be important for future distributed and stand-alone database applications.

INGRES 5.0 for PCs relies on the relational approach to database management and its standard Structured Query Language (SQL) to offer operational advantages over nonrelational systems (see "Lingua Franca for Databases," Richard Finkelstein, this issue, p. 52). It includes a nonprocedural fourth-generation application development language, INGRES/4GL, and Embedded SQL (ESQL).

INGRES for PCs is distinguished by:

- An *easy-to-use, PC-oriented*, menu-driven user interface and well-integrated tools. The product was written specifically for PC architecture, yet maintains the front-end common to all INGRES versions.
- Participation as the PC version in a well-developed distributed database system(INGRES/STAR) that includes mainframes, minicomputers, and PCs. It allows connectivity to multiuser hosts via INGRES/NET and to distributed databases via INGRES/STAR, introduced earlier this year, and it provides application portability to mainframes or minicomputers running INGRES.
- Support of transaction processing, security, integrity, and space allocation *only* when networked to a server that supports them, but not in the stand-alone version.
- Running on either and IBM PC, PC/XT, PC/AT, compatibles, or 80386-based machines with 640KB memory limit when in stand-alone mode.

Relational Technology Inc., a supplier of database management systems, is targeting the product at its currently installed base. The addition of a PC version enhances connectivity possibilities and offers a growth path for those organizations that will eventually outgrow their PCs. In addition, INGRES for PCs is well-suited to many stand-alone, single-user PC applications—which is the focus of this review.

**BASIS OF EVALUATION**

This review of INGRES 5.0 for PCs, and the one of ORACLE on page 108, evaluate the products by building a sample database devised by the editors of *PC Tech Journal*, the same one used in all articles in this series (see "Evaluating Data Managers as Development Tools," Julie Anderson, August 1985, p. 46).

An evaluation is done of elements common to data managers, such as number of files, columns (fields), and rows (records); number of diskettes supplied, ease of installation, and customization of the keyboard. Five *PC Tech Journal* benchmarks were run to measure product performance in data retrieval (including indexed and sequential), adding new records, updating data, and indexing. Also, because INGRES and ORACLE are relational data managers, features unique to relational systems are examined as they relate to mathematician E. F. Codd's 12 rules of fully relational data managers.

ILLUSTRATION • ANDY LEVINE

The PC version of INGRES complies with 6 of Codd's rules and partially meets 3 others (see table 1). At minimum, Codd defines a relational data manager as implementing SQL and an on-line system catalog that is tabular and accessible to SQL. Meeting these criteria fulfills 7 of Codd's 12 rules.

Like most vendors, Relational Technology has based its SQL on a combination of the American National Standards Institute (ANSI) "official" standard and IBM's more complete implementation. As a relational data manager, INGRES 5.0 is judged on SQL implementation, its system catalog, end-user facilities, application development tools, and on its documentation.

**TABLE 1:** ***Conformity of INGRES to Codd's Rules***

| RULE | INGRES ADHERENCE |
|---|---|
| 1. Information Rule | Yes |
| 2. Guaranteed Access Rule | Partial[a] |
| 3. Systematic Treatment of Null Values Rule | No |
| 4. Dynamic On-Line Catalog Rule | Yes |
| 5. Comprehensive Data Sublanguage Rule | Partial[b] |
| 6. View Updating Rule | No[c] |
| 7. High Level INSERT, UPDATE, and DELETE | Yes |
| 8. Physical Data Independence | Yes |
| 9. Logical Data Independence | Partial[d] |
| 10. Integrity Independence | No |
| 11. Distribution Independence | Yes[e] |
| 12. Non-Subversion Rule | Yes |

[a] *Lack of direct key support*
[b] *SQL restrictions (see implementation section)*
[c] *JoinDefs provide limited functionality*
[d] *Limited updatability of views*
[e] *Through INGRES/NET connection to INGRES/STAR*

**INGRES Release 5.0 for the PC conforms fully to six of Codd's rules for relational data managers. Only null and integrity support are both absent in the stand-alone PC version because the JoinDefs facility supports updates of two table joins.**

### OPERATIONAL OVERVIEW

INGRES requires at least 640KB of RAM and a 10MB hard disk. It runs under DOS 2.1 or later and operates with a dynamic memory allocation between 41KB (default size) and 64KB. Part of this memory is dedicated to a cache that can be set from 14KB to 20KB (default) when the ADDINGRES command starts the relational data manager. A query-processing buffer uses another 9KB of memory allotment, and the remainder is used for table descriptors, view processing, etc.

Like most relational data managers, INGRES has a memory-resident engine that drives front-end user interfaces (figure 1). Interfaces are accessible through the main menu so users do not have to leave INGRES to perform tasks, such as querying the database, developing applications, and writing reports. Interfaces are also available from DOS or from within applications.

End users can access an interactive, prompted Tables utility to create, modify, and delete tables; the Query-by-Forms (QBF) facility to query and maintain databases through system-generated menued forms; and the Interactive SQL (ISQL) monitor to issue direct SQL commands. Developers can use the Visual Forms Editor (VIFRED) to design or customize forms, Report Writer to customize complex reports, and Applications-By-Forms (ABF), an integrated development environment, to design sophisticated applications. ABF can access all INGRES modules, the full-function, nonprocedural 4GL, and a C interface for applications that embed SQL in C programs. All user and developer utilities are accessible directly or indirectly through the main menu (figure 2); all, except Tables and VIFRED, can be individually invoked from DOS and incorporated into applications.

### AN EASY INSTALLATION

Installation is straightforward via an Install program diskette provided with each INGRES module, and clear, step-by-step instructions in the accompanying *Installation Guide*. Complete installation of the 11 INGRES diskettes on an 8-MHz AT takes about 15 minutes; the 4 INGRES/4GL diskettes, 4 minutes; and the 4 ESQL diskettes, 4 minutes.

The Install program checks for sufficient RAM and disk space and then prompts for the disk on which to install INGRES. After installation, it prompts for money symbol, time zone, text editor of choice, and SQL or QUEL option. Install adds the \INGRES\BIN path statement to AUTOEXEC.BAT and sets files to 20 in CONFIG.SYS. It saves a copy of the existing files, AUTOEXEC.BAK and CONFIG.BAK, on the disk. The INGRES directory/subdirectory system set up by Install is clearly diagrammed in appendix C of the *Reference Guide*. After reboot, INGRES is ready to run.

In addition to the *Installation Guide*, INGRES documentation includes *Getting Started in INGRES*, an excellent introductory overview of both relational technology and the features available in INGRES and a tutorial that guides novices through design and use of an application. Each INGRES tool is accompanied by a manual detailing its use.

The *Reference Guide* details system-level commands, queries, forms, SQL language commands, and reports; presents command variations needed to use INGRES in a network or distributed system; and describes features existing on larger INGRES implementations that have not been brought to the PC. In addition, it presents a hierarchical diagram of each feature on the INGRES main menu, revealing options and facilities available and routes that INGRES uses to accomplish tasks (see figure 2). The guide is clear, concise, well indexed, and effectively organized, although it tends to be rather terse in places for beginners.

### THE SQL FOUNDATION

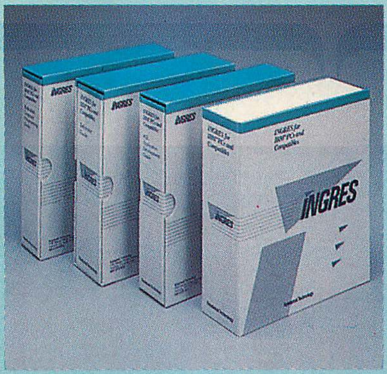
As the foundation of relational database capabilities, SQL should implement data manipulation, definition, and control languages; and it should support updatable views, transactions, and entity integrity (primary keys). Originally, Relational Technology developed QUEL, which is considered by some to be a superior language to SQL in that it is more readily optimized and precompiled and has a simpler relationship with predicate logic. Although the engine in INGRES 5.0 remains QUEL-based, industry standardization on SQL prompted INGRES support of it, by mapping SQL statements to QUEL. QUEL itself is a user option.

Even though both QUEL and SQL are multirow processing, genuine relational languages, perfect matching between them is not possible. Although this does not impair functionality, it explains some of the QUEL flavor of INGRES's SQL, such as CREATE PERMIT rather than SQL's GRANT command. Relational Technology says that INGRES version 6.0, slated for release in mid-1988, will have an SQL-based engine and will no longer require mapping.

## INGRES OVERVIEW

**INGRES 5.0**
*Relational Technology, Inc.*
*1080 Marina Village Parkway*
*P.O.Box 4006 Alameda, CA 94501*
*800/446-4737; 415/769-1400*
CIRCLE 343 ON READER SERVICE CARD

**Product description.** INGRES/PC is a truly relational, SQL-based database management system with comprehensive application development tools. It can be used in single-user local mode, or in remote mode connected through INGRES/NET to multiuser INGRES hosts or to INGRES/STAR distributed databases or through INGRES/PCLINK, for micro-to-host links. It has a visual, form-based application design approach; a command-based Report Writer; and a nonprocedural, compiled 4GLanguage.
**IBM PC environment.** IBM PC-XTs, ATs, and compatibles (the latter is recommended), DOS 2.1 or higher, 640KB RAM for a full module configuration, at least a 10MB hard disk, and a monochrome or color monitor.
**Other environments/network support.** Connectivity to UNIX, VMS, and VM INGRES database servers and application portability; support for the NETBIOS PC LAN environment currently not available.
**Copy protection.** Not copy protected.
**Documentation.** *Getting Started*, *Reference Guide*, *4GL Application Development Guide*, *Embedded Language Programming Guide*, *Installation Guide*, Sampler (diskette-based interactive tutorial), Quick Reference Card.
**User interface.** Dual-user interface based on forms with ring menus, as well as command driven [interactive SQL (ISQL), Report Writer, and 4GL]. It supports the tabular view of data, and is fairly consistent throughout. Forms/menus can be customized or passed as is to end users in applications. PC keyboard is well utilized and customizable by developers.




**Help facilities.** Context-sensitive, on-line help is available via F1, but is rather terse. Help screens callable from 4GL-coded menus can be created.
**File capacities.** Maximum number of databases, tables, and rows per table are limited only by disk space. A table can have a maximum of 127 columns and rows up to 2KB.
**Data types/capacities.** VCHAR (up to 2KB), MONEY (float), DATE (character), INTEGER (1, 2, 4 bytes), and FLOAT (4, 8 bytes).
**Data entry.** With SQL or from default or customized forms with limited validation and masking. Sophisticated editing operations with 4GL.
**Application development facilities.** Applications-By-Forms (ABF) is an integrated application development environment, which coordinates the use of INGRES modules, languages, system catalog, databases, the forms editor, a text editor of choice, Report Writer, a C interface, testing, and compilation. INGRES modules can be incorporated in applications and can include SQL. Modules can also be invoked from the operating system. Forms and applications compiled to executable images can be run with a RUN4GL module.
**Security.** Not implemented in local PC mode, but can be included in applications for remote use or ported to other INGRES systems supporting security
**Access to system facilities.** A DOS shell is provided through a function key in ISQL. Developers can pass a DOS shell to end users.
**Queries/sorting.** SQL queries can be saved in batch execution ASCII files, and combined in 4GL procedures. Query-By-Forms (QBF) provides default Query-By-Example forms for tables or JoinDefs. With SQL- and 4GL-based forms, multiple tables can be queried. SQL, QBF, and 4GL allow the user to order the results freely. QUEL is provided as an option.
**Reporting.** Ad hoc, simple table/view reports are generated as defaults. For more advanced needs, the Report Writer, with its own command language, manipulates and formats the output of SQL queries.
**Utilities.** Creating, destroying, importing, exporting, and listing tables, forms, reports, databases, and applications; loading and unloading the back-end data manager, and runtime execution of compiled applications.
**Data compatibility.** Data import/export from/to delimited ASCII files is available through a special SQL command (interactive or batch), which is also used to transfer data between INGRES databases. A Visual Query Language (VQL) provides host download/upload capabilities from/to PC file formats, through INGRES/PCLINK.
**Distribution.** Available directly from Relational Technology.
Base product (RDBMS and User Interfaces): $950
Applications (ABF/4GL): $500
C/ESQL preprocessor: $400
Networking support (INGRES/NET): $100
Asynchronous protocol support: $100
INGRES/PCLINK (PC Module): $200
**Support.** For-fee annual program updates; 90 days free post-purchase telephone support; optional for-fee annual telephone support.
*—Fabian Pascal*

SQL is used for all database accesses. SQL commands can be issued from the ISQL monitor, accessible from the Languages selection on the main menu or from DOS. SQL commands also can be saved in ASCII command files and executed interactively, or by invoking the batch processor module from the operating system as was done to perform the *PC Tech Journal* benchmarks. For example, the command file BENCH.SQL, containing SQL statements for benchmarking, was executed against the *PC Tech Journal* database, which consists of Authors, Issues, and Articles tables, as follows:

```
C> INGBATCH -SQL pctj <bench.sql
```

SQL queries retrieve data for reports. The Report Writer formats the output; INGRES then compiles the application to executable code. SQL can be embedded in C programs using ESQL (INGRES/ESQL); statements of an extended SQL version can be used in the IF THEN logic of INGRES/4GL.

**Managing data.** Most of the power of SQL comes from four data manipulation language (DML) commands, SELECT, INSERT, UPDATE, and DELETE. INGRES has a fair DML compared with other current data managers for the PC environment. Most of what is missing is largely due to lack of support of nulls and domains. A few other restrictions limit developers and users. For exam-

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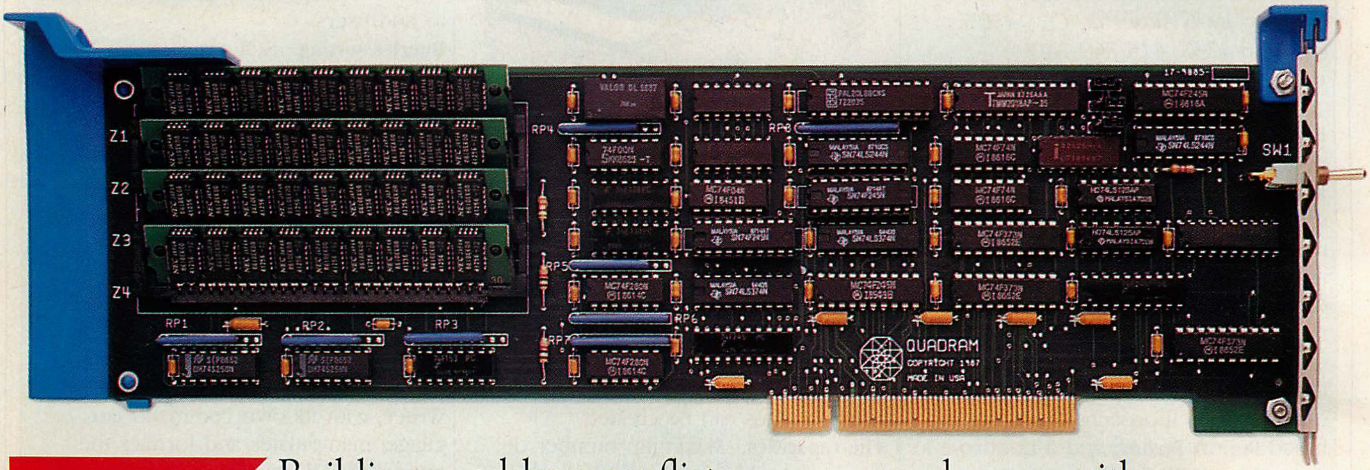

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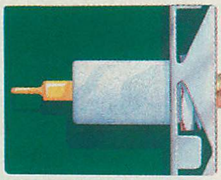

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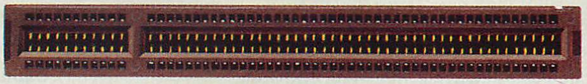
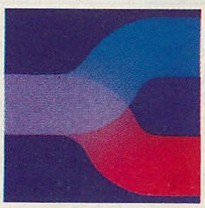


Rigorous new Quadram Tolerance Test means QuadMEG PS/Q connections are positioned to within 0.001 in. Trouble-free operation and no mis-connections.



Switch between expanded and extended memory.

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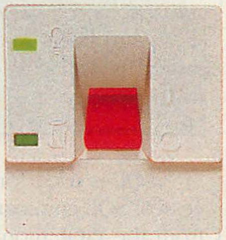
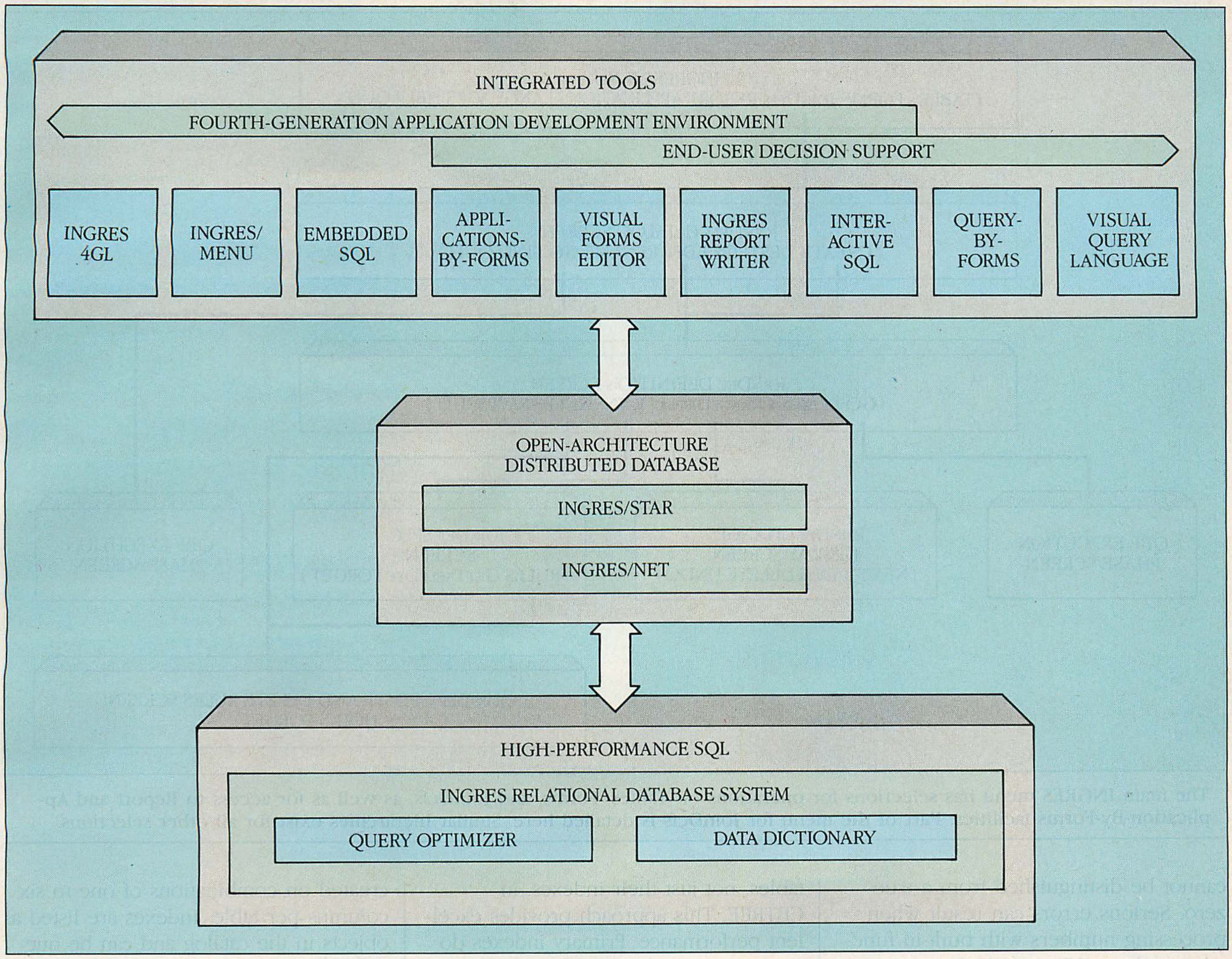


Total IBM PS/2 BIOS support means QuadMEG PS/Q starts up automatically when you turn on your Model 50 or 60.

**QuadMEG PS/Q**
by QUADRAM

**FIGURE 1:** ***Overview of INGRES's Facilities***




*Adapted from Relational Technology's INGRES Reference Guide.*

**INGRES's two major components are Tools for both application developers and end users and the data manager. Tools allow access to the data manager via Interactive SQL, Embedded SQL, applications developed in INGRES/4GL, screens, and forms.**

ple, the following query cannot be executed with INGRES's SQL

```
SELECT fee = payment + bonus
FROM articles
WHERE fee >
  (SELECT AVG(payment + bonus)
  FROM articles)
```

because built-in functions such as AVG are not allowed in a subquery. Similarly, an ORDER BY clause, used to sort the result in a user-defined sequence, unnecessarily requires the DISTINCT predicate, which eliminates duplicates from the result. Thus, if authors have identical names, the query will not reveal them because the required DISTINCT will reject duplicates:

```
SELECT DISTINCT lname, fname
FROM authors
WHERE state = 'DC'
```

Although there are ways around this, such as adding ssn to the selected columns to make the combination distinct, this is inconvenient and such useful columns are not always available or desired in the output. Although these sorts of restrictions complicate testing for SQL completeness, such testing is important because an incomplete SQL implementation can force developers into procedural code.

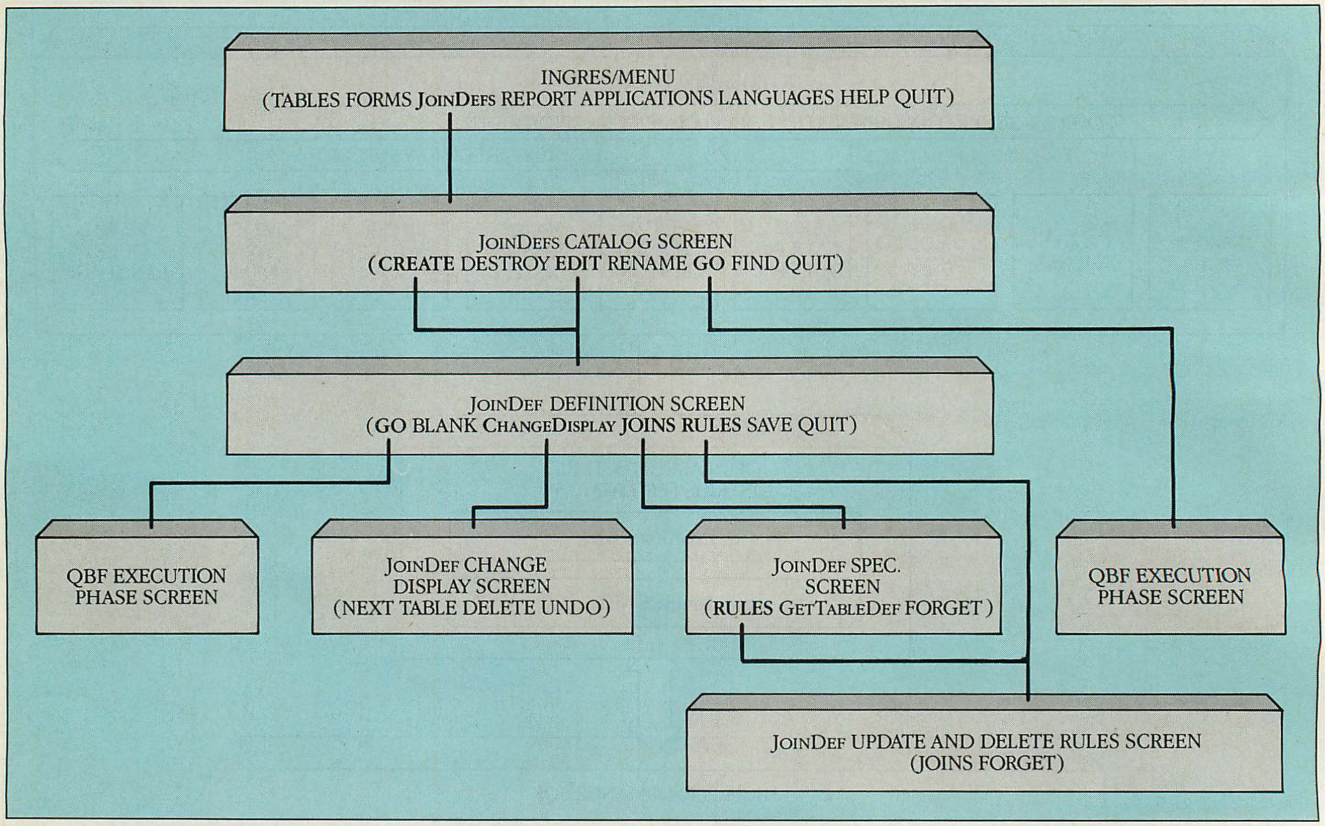
**Designing databases.** SQL is used to CREATE, ALTER, and DROP tables, views, and indexes via its data definition language (DDL). The ANSI standard defines only CREATE TABLE; INGRES defines both CREATE TABLE and DROP, but not the ALTER TABLE command supported by IBM's SQL (where it can only add a column to a table).

The structure of an existing table can be changed only through the Tables facility, entered from the main menu. GetTableDef allows users to copy unchanged columns to new tables, add changed or new columns to tables, and destroy old tables. This task is cumbersome but easy, especially because of a fill-in-the-blanks format that avoids DDL syntax.

In INGRES, the number of tables per database and rows per table are constrained only by disk space. Each table can have up to 127 columns; each row, up to 2,000 bytes in length. Data types supported by different SQL versions vary; in ANSI it is mostly implementor defined. Table 2 lists INGRES data types: one character, five numeric types, and the useful DATE and MONEY types which are not defined in ANSI (IBM only recently added DATE).

INGRES does not support nulls for missing or unknown data. Although the three-way logic underlying nulls (true-false-unknown/inapplicable) sometimes creates complications for careless users, the absence of nulls opens databases to serious integrity risks because a zero value used to represent a missing value

**FIGURE 2:** ***INGRES/MENU***




The main INGRES menu has selections for operations on Tables, Forms, and JoinDefs, as well as for access to Report and Application-By-Forms facilities. Part of the menu for JoinDefs is detailed here. Similar hierarchies exist for all other selections.

cannot be distinguished from a true zero. Serious errors can result when processing numbers with built-in functions such as AVE or MIN. In recognition of this, Relational Technology plans null support for version 6.0, which will also feature a DECIMAL type to support integers larger than the current maximum of 2,147,483,647.

Of eight storage structures supported on larger INGRES systems (HEAP, BTREE, CHEAP, CBTREE, HASH, ISAM, CHASH, CISAM), two are implemented on the PC for base (physical) tables: compressed HEAP (CHEAP) for small tables and compressed BTREE (CBTREE) for large tables. Tables are stored as CHEAP files by default, but can be changed to CBTREE using the MODIFY command. The system automatically creates a primary index for all tables stored in a CBTREE structure. The Authors table from the sample application can be modified from CHEAP to CBTREE by

```
MODIFY authors TO CBTREE UNIQUE
  ON ssn
```

This command not only changes the table's structure, but also creates a primary index on **ssn**. INGRES stores the tables, not just their indexes, in CBTREE. This approach provides excellent performance. Primary indexes do not appear as separate objects in the system catalog because they are part of the storage structure, not separate entities. Indexes are dropped by:

```
MODIFY table TO CHEAP
```

To reindex the table, another MODIFY is used. The remaining six storage structures can be specified in an application written for the PC version of INGRES, but will automatically convert to either CBTREE or CHEAP, whichever is the closest structurally to the one named. If applications are ported from the PC to larger INGRES systems supporting those structures, the statements will be properly interpreted and implemented. This technique allows INGRES to achieve portability without bringing unnecessary physical complexities to the PC version.

The SQL CREATE [UNIQUE] INDEX and DROP commands are used in INGRES for secondary indexes, which are composed of the field value and a tuple identifier pointer (TIDP) to associate each index with a record in the base table. Secondary indexes can be created on combinations of one to six columns per table. Indexes are listed as objects in the catalog and can be queried as tables by SQL. If a table is modified to CHEAP, the secondary indexes are also dropped.

Logical tables, called *views*, can be created by joining two or more tables over common fields or by selecting specific fields from one table. These view tables are critical for achieving logical data independence in relational systems. For example, the following SQL statement creates a view named **v_dead**. In the *PC Tech Journal* sample application, this view is defined over the joined Issues and Articles tables with data selected only on articles received after the deadline:

```
CREATE VIEW v_dead (volume, number,
  deadline, titled, received)
  AS SELECT i.volume, i.number, i.deadline,
    a.title, a.received
    FROM issues i, articles a
    WHERE a.volume = i.volume AND
      a.number = i.number
    AND a.received > i.deadline
```

Once defined, the query "Which articles per issue were received after deadline?" uses the view

*Continued p. 87*

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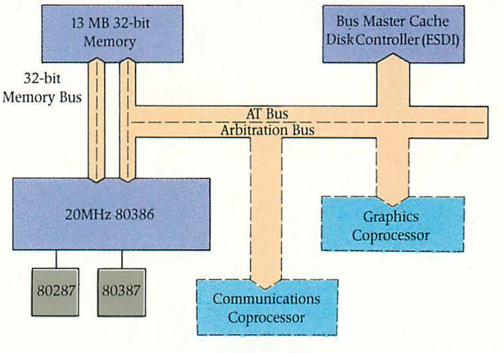
*AST Premium/386 Architecture*

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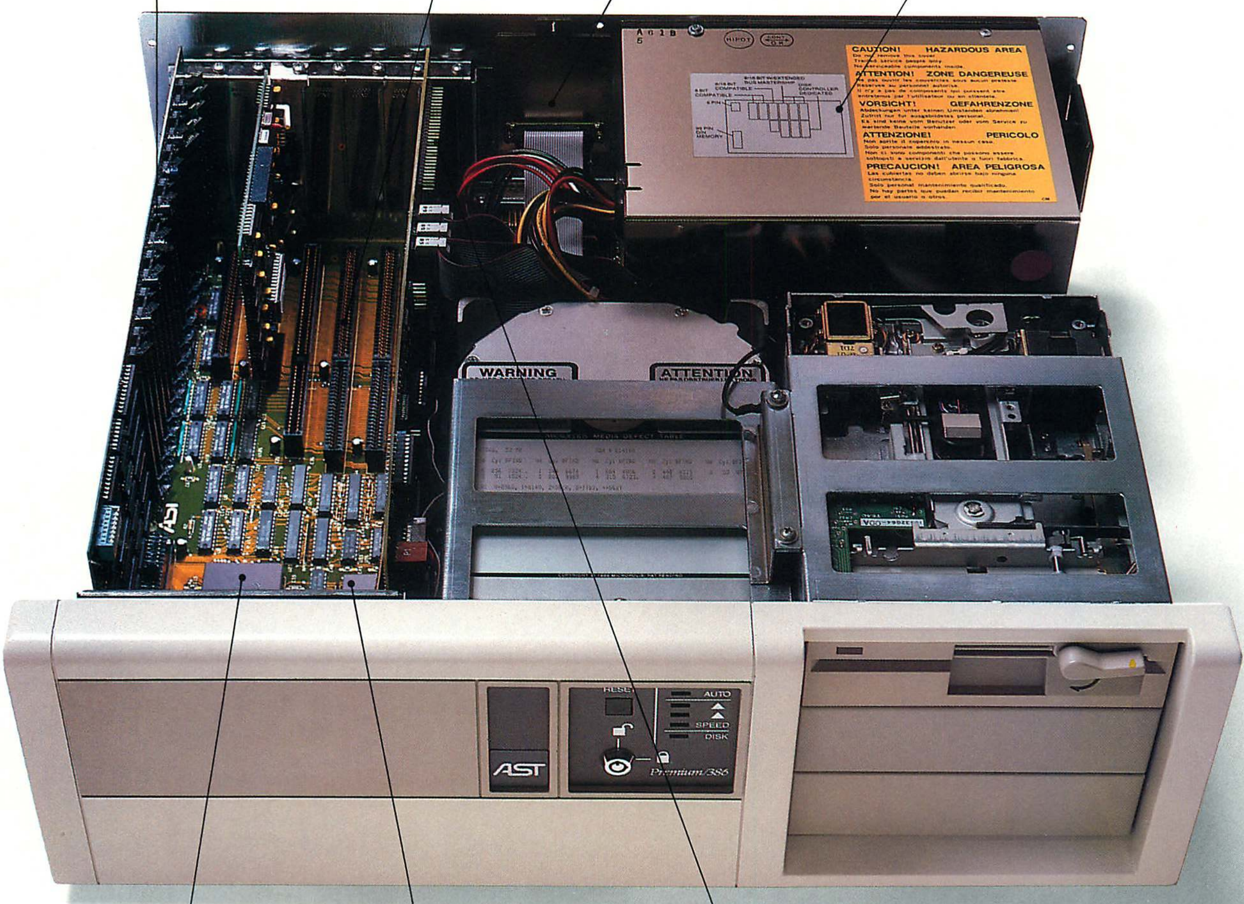


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| | AST Premium/386 | AST Premium/286 | AST Premium Workstation |
|---|---|---|---|
| Microprocessor | 80386 | 80286 | 80286 |
| Speed (MHz) | 20† | 10, 8, 6 | 10 |
| Wait States | 0-1 | 0 | 1 |
| Standard Memory | Up to 2 MB | 1 MB | 1 MB |
| Expandable to | 13 MB | 13 MB | 4 MB |
| Video Adapter | Optional | VGA/EGA/HGC (most models) | VGA/EGA/HGC module |
| Expansion Slots | 7* | 7** | 2 |
| Fixed Disk | 40, 90, 150 MB | 20, 40, 70 MB | 40 MB |
| Diskette Size and Capacity | 5¼," 1.2 MB<br>3½," 1.44 MB | 5¼," 1.2 MB<br>3½," 1.44 MB | 5¼," 1.2 MB<br>3½," 1.44 MB |

*† Three software selectable speeds for timing-sensitive programs.*

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**TABLE 2:** *INGRES Data Types*

| | STORE | MINIMUM | MAXIMUM |
|---|---|---|---|
| VCHAR | 2,000 bytes | | |
| INTEGER1 | 1 byte | −128 | 127 |
| INTEGER2 | 2 bytes | −32,768 | 32,767 |
| INTEGER4 | 4 bytes | −2,147,483,648 | 2,147,483,647 |
| FLOAT4 | 4 bytes | 8.43E−37 | 3.37E+38 |
| FLOAT8 | 8 bytes | 4.19E−307 | 1.67E+308 |
| MONEY | Float | −999,999,999,999.99 | 999,999,999,999.99 |
| DATE | 12 bytes | 1-Jan-1582 | 31-Dec-2382 |

The data types provided in INGRES are all the common data types, including one character type, five numeric types, and the useful MONEY and DATE.

```
SELECT *
FROM v_dead
```

rather than the full SELECT, thus simplifying retrieval. This view helps ensure security because users can access only data specifically allowed by the view, rather than all the tables.

View definitions are stored in the catalog and can be manipulated (except for multitable updates) as if they were physical tables. Views do not occupy disk space. Because views are formed ad hoc from physical tables, updating the physical tables means views automatically have updated information. If physical tables are changed in structure, applications or queries using views are not affected. Queries and applications should access tables through views as much as possible to minimize maintenance when the logical structures of databases change.

**Security controls.** SQL's security component can grant and revoke user privileges to resources (tables/views), their subsets (rows and/or columns), or specific data operations on them (creation, indexing, retrieval, updates). INGRES uses QUEL syntax (CREATE PERMIT/ DESTROY PERMIT) rather than the standard GRANT/REVOKE, and extends privileges not only to users, but also to hours, days, and terminal IDs. INGRES's security component, data control language (DCL), is not implemented on PCs in stand-alone mode, but applications written on PCs can contain security controls as no-operation (no-op) instructions (statements that are accepted and ignored). When such applications are ported unchanged to any other INGRES system or run on a network where the server supports DCL, the instructions will work.

## THE SYSTEM CATALOG

Relational data managers require an on-line system catalog to keep information on the database current and provide it to users (administrators, developers, and end users with proper authority); applications; the SQL processor, which analyzes correctness of processing request and their intent; and the optimizer, which estimates the most efficient access path. Developers can also include queries of the catalog in applications to avoid having to code their own facilities in order to obtain information on tables.

INGRES's catalog works superbly within the system but it is not that informative for users. The catalog stores extensive information about all database and application objects such as tables, views, indexes, columns, forms, applications (including compiled versions), and form labels. However, the system uses the information exclusively for analyzing user requests and for accessing data and applications. INGRES's excellent performance is traced, in large part, to the wealth of catalog information (such as indexes and row statistics) available to the optimizer. In some cases, tables need not be accessed because the information in the catalog is sufficient to complete the task at hand. For example, the COUNT function returns the number of rows in a table and INGRES stores this information in the catalog.

The catalog is also useful when databases or applications must be transferred across systems. INGRES provides utilities to copy catalog information into ASCII script files, which the receiving system can use to regenerate the objects (see "utilities," described below). In most data managers, catalog tables are given meaningful names, such as SYSTABLES, SYSCOLUMNS, and SYSINDEXES, but to maintain compatibility with other INGRES versions, Relational Technology continues to use some less-intuitive terminology, which is not as helpful when users interrogate the catalog. For example, INGRES uses IIID, IIQBFINFO, ABFAPPL, and ABFOBJS. These unusual names, in addition to a shortage of documentation and lack of integrated access to the catalog from one place, lower the INGRES system catalog's overall value to developers and users.

## INTEGRATING INTEGRITY

Data integrity is an integral element of the relational model: entity integrity ensures uniqueness of primary key values that cannot be null; referential integrity ensures that foreign key values cannot be null and must match primary key values; and user-defined integrity places restrictions on the way a table can be updated, thus ensuring that data entered conform to user specifications.

Most vendors, including Relational Technology and IBM, enforce entity integrity indirectly through unique indexing, rather than directly, like ANSI, with primary keys explicitly defined for tables. In INGRES, the MODIFY command enforces uniqueness in one or more specific columns with UNIQUE ON. Without the UNIQUE ON command, MODIFY imposes uniqueness on the first column in the table by deleting any rows with duplicate values. This means that rows in it cannot have identical values in their first column in a CBTREE-stored table unless another unique combination of values exists in the row and is specified by the user in the MODIFY command. This is entirely consistent with the relational model, which insists that base tables must have unique primary keys.

To date, no vendor supports referential integrity in a direct and complete way. See C. J. Date's book, *Relational Data Base: Selected Writings* (Addison-Wesley, 1986), for a proposed framework for such support.

User-defined integrity is not supported by INGRES for the PC stand-alone version and, like DCL statements, can be incorporated into portable applications only as a no-op instruction. Other INGRES implementations can support it by means of a CREATE INTEGRITY/ DESTROY INTEGRITY command in QUEL syntax. The command includes a table name and a condition specifying constraints. INGRES assigns an identification number to each one. In order to drop a constraint, the command HELP CONSTRAINT is used to get the ID; then, integrity is dropped for that ID.

## TRANSACTIONS AND RECOVERY

Transaction support is as critical to a single-user system as it is to a mul-

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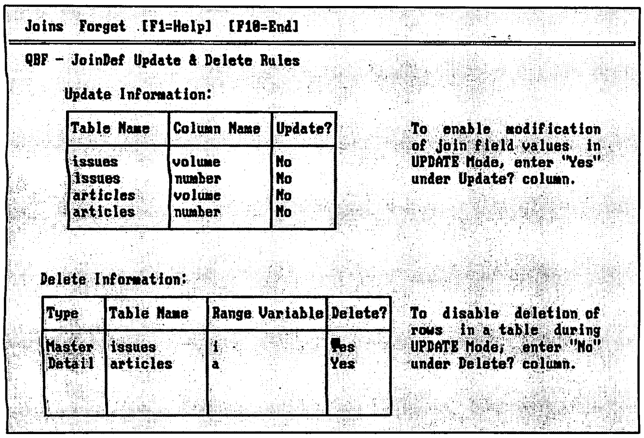
**PHOTO 1:** *JoinDefs Rules Specifications*


Joins Forget [F1=Help] [F10=End]

QBF - JoinDef Update & Delete Rules

Update Information:

| Table Name | Column Name | Update? |
|---|---|---|
| issues | volume | No |
| issues | number | No |
| articles | volume | No |
| articles | number | No |

To enable modification of join field values in UPDATE Mode, enter "Yes" under Update? column.

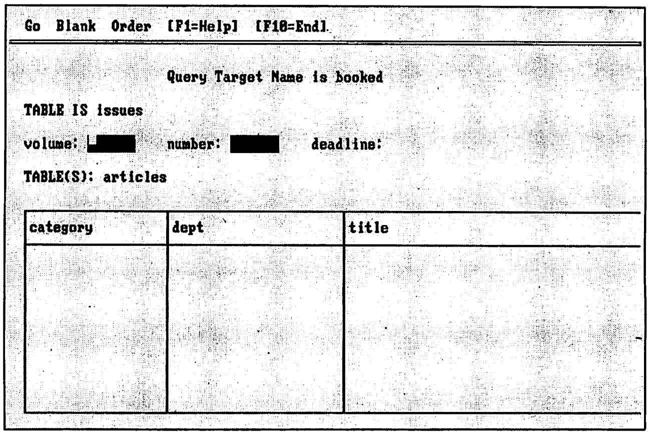
Delete Information:

| Type | Table Name | Range Variable | Delete? |
|---|---|---|---|
| Master | issues | i | Yes |
| Detail | articles | a | Yes |

To disable deletion of rows in a table during UPDATE Mode, enter "No" under Delete? column.

JoinDefs are updatable predefined joins. The Rules option instructs INGRES on how to maintain consistency when simultaneously updating the **booked** JoinDefs that joins the master table called Issues with the detail table Articles.

**PHOTO 2:** *QBF Default JoinDefs Form*


Go Blank Order [F1=Help] [F10=End]

Query Target Name is booked

TABLE IS issues

volume: number: deadline:

TABLE(S): articles

| category | dept | title |
|---|---|---|

INGRES's QBF facility generates default forms, such as the **booked** JoinDefs, showing fields from both tables. Because this is a one-to-many relationship, the default form has a table-field window to display the articles in each window.

tiuser system because any partial execution of a set of statements that must be executed together will corrupt the database. INGRES does not implement multistatement transactions on the PC, but, like user-defined integrity, they can be included into applications that are portable to other INGRES systems. INGRES uses the QUEL format END TRANSACTION/ABORT, rather than the SQL standard COMMIT/ROLLBACK. Issuing an END TRANSACTION statement using the PC version of INGRES commits current action immediately rather than when the buffers become filled (the default). SET AUTOFLUSH has the same effect and is the best way to prevent database corruption when single SQL statements are executed.

INGRES has an automatic-recovery mechanism on the PC, but only for system crashes or involuntary reboots. Should these occur, the system will check the catalog upon rebooting and will roll back incomplete actions that have corrupted the database. Without transaction support, it will not roll back statements that have completed even if other accompanying statements have not. Because *journaling*, the recording of all modifications applied to the database, is not implemented on the PC (another no-op instruction), the database cannot be restored to the beginning of a transaction. However, if the PC application runs on a network where the server supports journaling, the instructions will be executed. This is also true for transaction processing.

Optimizers and the catalog data available to them contribute to system performance. To make access decisions, INGRES's sophisticated optimizer uses system catalog information on index availability and table-related statistics (number of unique column values and value distribution in indexed columns). INGRES's excellent performance is due largely to its optimizer.

Tests show that INGRES's optimizer is difficult to fool; that is, even when the order of items in the SELECT item list is changed or the order of tables in the FROM or conditions in the WHERE are changed, performance is consistent. INGRES's performance is consistent across various types of operations, including the unindexed mode, where some other data managers fail.

## FLEXIBLE EXTENSIONS

Vendors attempt to extend their SQL beyond the IBM and ANSI standards to increase its functionality. The most common extension is to string manipulation. (The ANSI and IBM standards offer only the LIKE predicate for pattern-matching searches.) In INGRES, the extension of LIKE is

*Standard:*

```
SELECT lname, fname
FROM authors
WHERE lname LIKE '%son%'
```

*INGRES:*

```
SELECT lname, fname
FROM authors
WHERE lname = '*son*
```

where % and * are the respective multiple-character wild cards. This query retrieves the names of all the authors in the file that contain *son* in their last names. Relational Technology offers other string-manipulation extensions that are important for mailing lists and other applications that have intensive-character data use.

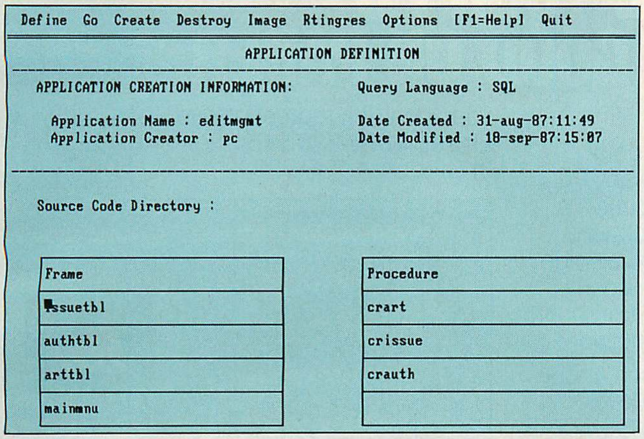
INGRES also offers command extensions to SQL. The COPY TABLE command imports/exports data in delimited ASCII files, backs up/restores databases, and exchanges data among them. The example below loads AUTHOR.ASC by *PC Tech Journal* into the Authors table:

```
COPY TABLE authors
    (lname = VCHAR(0)COMMA,
     fname = VCHAR(0)COMMA,
     address = VCHAR(0)COMMA,
     city = VCHAR(0)COMMA,
     state = VCHAR(0)COMMA,
     zip = VCHAR(0)COMMA,
     wphone = VCHAR(0)COMMA,
     hphone = VCHAR(0)COMMA,
     ssn = VCHAR(0)COMMA,
     bio = VCHAR(0)NL)
FROM "a:author.asc"
```

COMMA indicates that the file being loaded is delimited by commas. INGRES automatically converts data to types defined in the table, assuming that data in the ASCII file are compatible. Another useful command extension is HELP, for displaying either database information or user instructions.

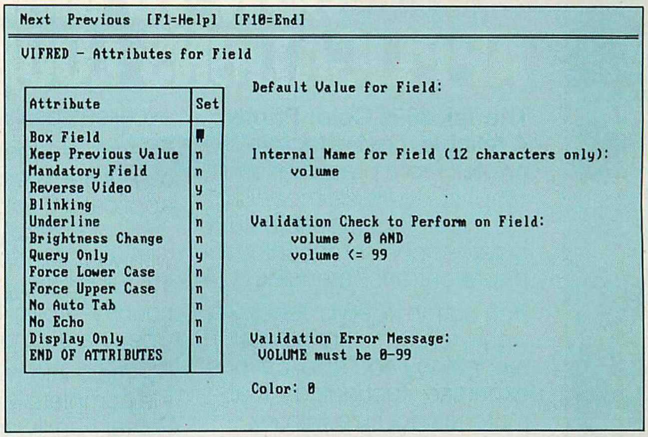
One important external extension to INGRES's SQL is JoinDefs, which permits simultaneous updating of two joined tables. Standard SQL does not allow updating for columns in a view's WHERE clause, views containing columns that are computed or based on built-in functions, and multiple-table views. However, using JoinDefs allows INGRES to update two-table views determined to be theoretically updatable, effecting a limited fulfillment of Codd's view-updating rule.

**PHOTO 3:** *Applications-By-Forms Screen*




The INGRES/4GL language is accessed from INGRES's Application-By-Forms (ABF) application development environment. On the main ABF screen for the *PC Tech Journal* application, frames are shown at left, procedures at right.

**PHOTO 4:** *The VIFRED Screen*




The default form for the JoinDefs, **booked**, can be customized using INGRES's Visual Forms Editor, VIFRED, a menu-driven facility for customizing forms. Attributes such as brightness, blinking, and box enclosure can be set.

JoinDefs is available from the INGRES main menu or from the QBF start-up screen. It uses a special menu-driven facility with fill-in-the-blank screens, allowing users to specify tables to be joined, type of join (master-to-master, master-to-detail), columns, and any referential integrity. JoinDefs cannot be used in SQL statements, but can be used as data targets in form-based operations, including updates.

Photo 1 shows the JoinDefs rules specification screen, where a JoinDefs named **booked** is defined over the Issues (master) and Articles (detail) tables. It was used for the query "What articles were booked for a given issue?" The tables are prejoined on the volume and number columns, common to both, and the columns selected for the view are **volume**, **number**, **title**, **comm**, **epages**, and **pages**. The rules screen prompts for instructions on whether (and how) to update the joining columns using JoinDefs.

Due to its 640KB memory limitations, INGRES can produce only master-to-master and master-to-(one)detail JoinDefs despite implications in the manual that more than one detail table can be joined to a master, or even to other detail tables. Without this memory limitation, more than two-table JoinDefs could be supported as in larger INGRES systems.

## END-USER FACILITIES

While SQL benefits end users, they do not need to become involved in its syntax in INGRES (although they can using ISQL). The main end-user feature in INGRES that shields end users from directly issuing SQL commands is QBF, which Relational Technology refers to as visual programming. QBF is a menu-driven module for generating forms on the screen (similar to forms on paper), allowing end users to add, delete, change, and view data. It generates default forms that are used to query and maintain databases; thus, it is a form-based ad hoc query/update facility for users who wish to avoid SQL. The forms generated by QBF take a Query-By-Example (QBE) approach: users place examples of data to be retrieved/updated in appropriate form fields, specify sorting criteria (if any), and then INGRES retrieves the data, handles the display (scrolling multiple rows where necessary), and allows users to add/update/delete as necessary, all by means of top-ring menus. Boolean operators (one per field) and pattern matching can be used for searches within form fields.

To invoke QBF, users select Forms from the main menu, followed by Query-By-Forms from the next menu. INGRES prompts users to select a data target type (table, view, or JoinDefs) and then provides a list of names in the type selected. For tables/views, INGRES prompts for display format; users can display one row at a time or a table of many rows. With JoinDefs, simple fields (master, one row) and table fields (detail, many rows) can be displayed on the same QBF form.

When a target and format have been selected, INGRES displays an Append/Retrieve/Update menu (QUEL terminology). Photo 2 shows the form generated by this simple process for the **booked** JoinDefs' target. QBF forms are valuable when using individual tables, simple views, or JoinDefs not requiring complex data validation, data manipulation, or refined esthetics.

Another plus for INGRES end users are contextual HELP screens accessible via a function key. Although screen information is terse, developers can tailor them by creating text fields and displaying them from menus in applications developed with INGRES/4GL.

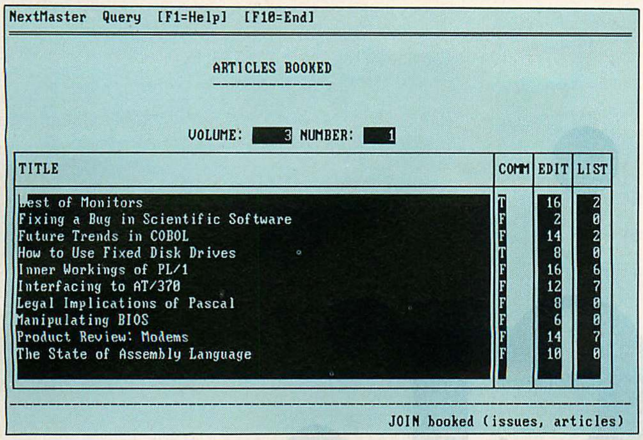
Error messages in INGRES deserve serious attention from Relational Technology. Many error messages appear in a technical language, having to do with internal system operation, rather than user-pertinent information. A message's relevance to what users are doing is not always clear, nor are directions toward a solution. INGRES also has an annoying habit of generating several error messages in sequence and of displaying them when a simple prompt for the Enter key would lead to continued operation. Finally, error messages are not documented in the manuals.

## APPLICATION DEVELOPMENT

For developers who need more advanced features to code complex applications, INGRES provides the host programming interfaces—ESQL and ABF.

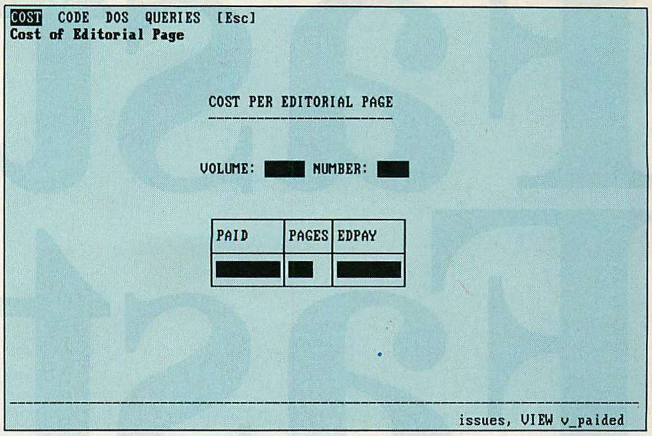
INGRES/ESQL, which embeds SQL statements into C programs, includes all SQL commands available in ISQL and allows access to the INGRES Forms Runtime System (FRS), which manages use of QBE and VIFRED forms within applications. INGRES/ESQL also allows developers to use the complete range of host-language facilities. Call statements allow access to all INGRES modules such as QBF, VIFRED, ABF, ISQL, INGRES/MENU, DOS, and Report Writer; the

**PHOTO 5:** *A Customized JoinDefs Form*




A customized form for the JoinDefs, **booked**, was designed for the *PC Tech Journal* application using INGRES's Visual Forms Editor, VIFRED. The result shows the titles of articles in Volume 3, Number 1 (January 1985) of *PC Tech Journal.*

**PHOTO 6:** *A Customized Form with Menu*




A frame consists of a form, a menu, and operations that can be triggered. The customized menu for determining cost per editorial page per issue of *PC Tech Journal* was developed using the INGRES/4GL code shown in listing 1.

SQL Communications Area (SQLCA) allows testing and branching after execution of ESQL statements.

The procedural, one-row-at-a-time orientation of C does not take full advantage of the set-level benefits of SQL, but ESQL provides cursors for processing multirow tables retrieved by ESQL commands. The cursor is a pointer set logically just above the first of a set of records returned. The FETCH statement moves the cursor to the next record and loads data from that record into host variables. Cursors can be used within transactions when a PC is running against a database on a host that has transaction support.

Access to FRS within ESQL allows developers to design forms-based applications so that end users can use forms to enter and select data. FRS handles all details such as moving data transparently in and out of fields. The host language, ESQL, and FRS can be used to design operations such as form initialization, and menu item, field, key, column, and scroll activations.

Most vendors are working to provide the high power of ESQL without the difficulties of procedural code; Relational Technology has an excellent approach with ABF and INGRES/4GL. Applications-By-Forms (ABF), accessed from the INGRES main menu, is a complete development environment that provides integrated and coordinated use of all INGRES features for writing, testing, and running applications. These features are system catalog, data, forms (QBF default and INGRES/4GL customized), forms editor (VIFRED), INGRES modules and languages (SQL or QUEL), Report Writer, various files, a text editor of choice, C interface, and testing and compilation facilities.

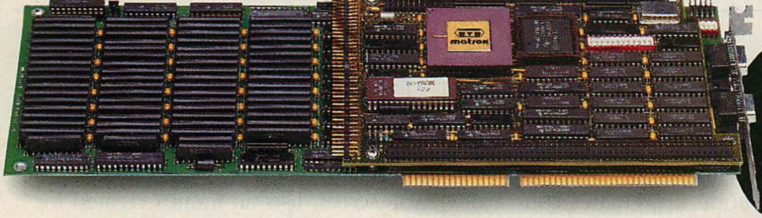
Applications in INGRES are combinations of procedures and frames that are created, maintained, tested, and compiled within ABF. Frames consist of forms, menus, and operations triggered from the menu, while procedures are 4GL routines that do not involve forms. QBF frames have default forms, menus, and operations (Append, Retrieve, and Update) generated by the system (see photo 2). For simple database operations, QBF frames can be incorporated directly into applications, simplifying development considerably.

For advanced applications, forms and menu/operations can be customized for frames. VIFRED can be used to customize forms and INGRES/4GL to customize menus and operations. User frames are customized with 4GL; they can display and manipulate data or provide menus from which other frames, INGRES modules (such as QBF or ISQL), a DOS shell, or 4GL procedures can be called. Report frames can be customized using INGRES's command-driven Report Writer.

**Application-By-Forms (ABF).** The ABF facility is accessed either from the Applications option of INGRES's main menu or directly from DOS. Developers must already have a finalized design (database structure, functions, menus, and so on) for the application (see sidebar, "Normalizing Databases," p. 95). In ABF, tables can be created by using SQL or the Tables utility, which is accessible through ABF's Define option. Views and indexes must be created with SQL and JoinDefs. Both ISQL and JoinDefs can be invoked from ABF through INGRES's main menu. If ABF is called from DOS, the RTINGRES option on its menu can be used to switch to the INGRES menu. In photo 3, the bottom left-hand scrollable section on the ABF screen lists all frames created for *PC Tech Journal*'s **editmgmt** application. The right-hand section lists procedures. ABF maintains and displays creation and modification dates of the application and each of its objects.

Development involves an object-by-object, menu-driven sequence of operations whereby developers (1) define an object by specifying its type (table, frame, procedure, or entire application), its name, a frame's type (QBF, user, or report), the name of the form associated with a frame and, for QBF frames, specific options and parameters; (2) invoke VIFRED to design or customize forms; (3) invoke a text editor of choice to write 4GL code for user and report frames and for procedures; (4) execute an object to test it; (5) repeat steps 2, 3, and 4 until an object operates satisfactorily; and (6) compile an executable image of the application that can be run from DOS with the RUN4GL facility.

**Visual Forms Editor (VIFRED).** An INGRES form displays top-ring menus, and consists of *trim* (labels and text that are not data) and data windows, which can have simple- or table-field format. VIFRED can be used to customize display attributes, initialization, validation checks, and cursoring for the form fields, all of which have defaults set by QBF for system-generated forms. VIFRED also can be used to design (from scratch) menu frames, whose sole function is to provide menus, not display



or manipulate data, or frames whose forms are significantly different from those of the default. Custom menus and operations to be triggered from user forms can be developed with 4GL. QBF frames can use forms customized with VIFRED, and user frames can operate with QBF default forms, giving developers considerable flexibility.

With VIFRED, form customization is an entirely menu-driven process; developers can create form objects (trim, simple, or table fields, or lines), delete them, edit field data windows and attributes, move them around on the form, order them in cursoring sequence, and save the form. The customization process begins either with a QBF default form or a blank form.

The default form named **booked** (photo 2) was customized for *PC Tech Journal*'s sample application. Photo 4 shows the VIFRED screen used for editing the volume field's attributes. The screen has various entry, display, and cursoring options; field default values and validation checks, including an error message, can be set. Using the top menu options Next and Previous, users can move from field to field (separately for simple and table fields) and can apply the desired settings to each. See photo 5 for customization results. VIFRED is powerful, yet easy to use. Its data validation facilities would be strengthened by adding masking (pictures) and table look-ups.

**INGRES/4GL.** To customize menus and operations for user frames and procedures in INGRES, developers can use INGRES/4GL, a full function, nonprocedural, set-oriented application development language. Developers specify goals, not the steps to reach them, resulting in code that is easy to write and maintain. Sets of data, rather than single rows, can be manipulated at one time.

INGRES/4GL is used primarily for controlling application flow and developing custom menus and triggers that activate operations from forms when such operations are too involved for, or are not possible in QBF. Because JoinDefs can handle only two tables, 4GL is required for simultaneous maintenance of more than two tables.

Typically, a 4GL program has a form initialization section and menu/field/key (activations) triggers, each containing one or more 4GL statements within a BEGIN IF ELSE END structure. Various 4GL statements exist for:

- Form control (display mode, clearing, cursoring, help access, messaging and prompting, value assignments, and validation).
- Flow control (initialization, activation, and calls of frames, procedures, INGRES modules, or a DOS shell).
- Inquiry statements to retrieve values of status and system variables.
- Database statements, which are extended SQL statements to perform operations on the data.

The 4GL code in PAIDED.OSQ (listing 1), for a user frame named **paided**, is used in the sample application for the query "How much did we pay per printed page for editorial in an issue, for articles that were not departments?" It puts the form, also called **paided**, into query mode, and provides actions to be triggered by COST, CODE, DOS, and QUERIES and by the Esc key. The COST option triggers the query, composed of two SQL SELECT statements. The query is based on a master-to-detail JOIN of the Issues table with the **v_paided** view on the volume and number columns. The view is defined over selected columns in the nondepartment rows in the Articles table. The QUALIFICATION key word is an SQL extension for 4GL that gives the form QBE capabilities, allowing use of Boolean operators and pattern searches in the form's fields. The Next submenu selection is then used to scroll through the multiple rows retrieved.

The rest of the code is optional. The CODE menu option executes a HELPFILE statement to display the text file PAIDED.OSQ, which contains the 4GL code for the form. This method is used to access custom help files in INGRES applications. The DOS option provides access to DOS by calling a shell (SYSTEM), and the QUERIES option returns the user to the frame that called the **paided** frame (the queries menu frame). Pressing the Esc key

## NORMALIZING DATABASES

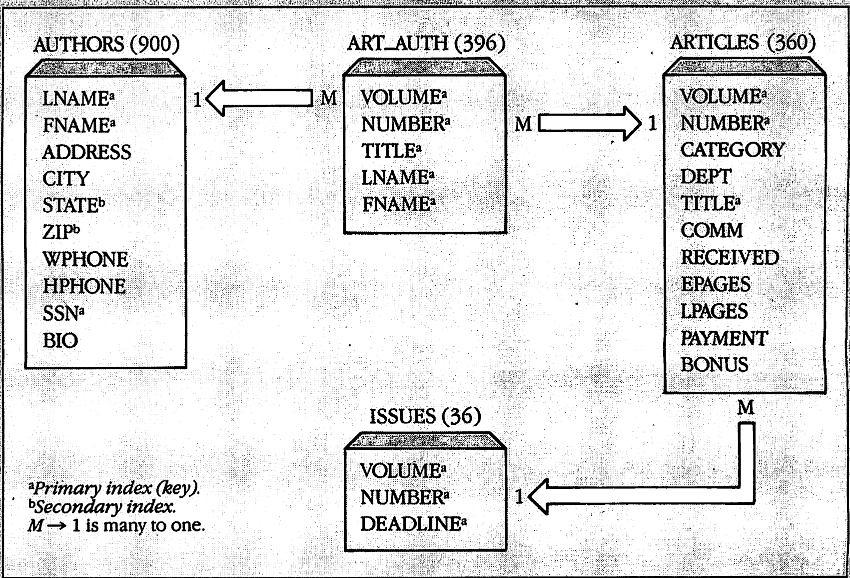
To benefit from the set-processing power of Structured Query Language (SQL) and optimization, relational databases must be normalized.

Normalization is assignment of data fields to tables such that data are not duplicated. Without it, procedural code might have to be written (and maintained) to manipulate tables one row at a time rather than sets as defined in the relational model.

A classic normalization issue is several authors per article. Author names repeated in more than one table in *PC Tech Journal*'s sample application are moved from the Articles table to a new Art_auth table, which relates the Articles and Authors tables. All columns in Art_auth are part of its primary key and act as foreign keys, linking Art_auth to Articles, Issues, and Authors tables (see figure). Any number of coauthors is possible with this configuration.

—*Fabian Pascal*

**FIGURE:** *Sample Tables After Normalization*




All the data tables for *PC Tech Journal*'s sample application were normalized by moving the authors names from the Articles table to the new Art_auth table.

moves the cursor to the menu. Photo 6 shows the custom form, with the menu generated by this 4GL program.

Another example demonstrating the power of 4GL is the UNLOADTABLE function for updating data from a table field. It can use the contents of a system variable called _STAT, storing the status of a row (new, unchanged, changed, or deleted) within an IF ELSE structure. For example, UNLOADTABLE could maintain the many authors in the Art_auth table per one article in the Articles table, as in the following code:

```
'Maintain Names_In_Art' =
BEGIN
UNLOADTABLE names (rowstat =
    _STAT)
  BEGIN
  IF rowstat = 1 /* undefined */
    INSERT INTO art_auth (lname,fname)
    VALUES (:names.lname, :names.fname);
  ELSEIF rowstat = 3 /* changed */
    UPDATE authors
    SET lname = :names.lname, fname =
        :names.fname;
    WHERE lname = :artmnt.lname AND
        fname = :artmnt.fname
  ENDIF;
  END;
END;
```

where **:artmnt.lname** and **:artmnt.fname** are hidden columns on the form that store data originally retrieved from the database, but now need to be updated. INGRES automatically executes a loop for each row in the data set, performing either the INSERT or the UPDATE statements from SQL. Users do not code any loops because of set processing and nonproceduraIity.

Procedures are also written in 4GL but they do not involve forms. Several procedures were used to create (and load from ASCII files) the tables involved in the *PC Tech Journal* application. Each procedure combined CREATE TABLE and COPY TABLE SQL statements, which require no screen displays and, thus, no forms.

Code for one procedure, for the two article data tables (Articles and Art_auth), is given in ARTAUTH.OSQ (listing 2); The 4GL method of triggering the procedure from the **arttble** menu frame using CALLPROC is shown in ARTTBL.OSQ (listing 3).

Similar statements exist for invoking other frames (CALLFRAME), INGRES modules (CALL QBF), or a DOS shell (CALL SYSTEM). A parameter can be passed upon triggering or returning from such calls. ABF automatically attaches an .OSQ extension to every 4GL program file created with the EDIT option. Upon execution, these files are checked and parsed. Their SQL statements are converted to QUEL equivalents and saved as compilable source files with an .OSL extension. All .OSL files in an application can then be compiled into one executable image file, bearing the extension .IMG.

Testing, debugging, and compiling in ABF are sometimes tedious. Executing one user frame or procedure causes ABF to parse all files in the application one by one; if any has errors, none can be executed. When errors are identified, ABF scrolls them on the screen. Users would have to be very fast in pressing Ctrl-S to stop scrolling long enough to read the messages one-screen at a time.

Once an error is found, ABF usually cannot digest the rest of the code so that the error list following the first error includes dummy errors stemming from the first, forcing users to determine which are real. To debug 4GL code, developers must note the errors, use the INGRES EDIT option to switch to the text editor, correct the code in the .OSQ file, and then try again.

*PC Tech Journal*'s compiled **editmgmt** application can be executed from the command line, as follows:

```
C> RUN4GL pctj editmgmt mainmnu
```

where **pctj** is the database name, **editmgmt.img** is the executable file compiled by ABF, and **mainmnu** is the start-up frame for the application. Start-up frames can be varied, allowing developers to control levels at which different users can enter applications.

Several bugs were encountered in INGRES/4GL during development of the sample application that initially prevented compilation of several modules. However, Relational Technology provided a diskette with corrections; it is part of the regular maintenance upgrade of INGRES for release in the fourth quarter 1987.

**Report Writer.** Reports are produced in two ways. Simple table or view ad hoc reports are generated quickly by selecting Tables from the main menu and then REPORT from the Tables screen.

Custom-formatted reports are generated using Report Writer, which has its own command language, entered from ABF. The design process is similar to that of user frames in 4GL. The user defines a report frame, then invokes the text editor to write report specifications in the Report Writer's own language for the frame. ABF saves the specifications in a text file with a .RW extension. These files are compiled into the database with the special utility SREPORT, available as an option on the report frame specification screen menu.

Report Writer is powerful, the language used is obvious and intuitive, and it is unlikely to fail even during complicated reports. It primarily manipulates and formats the output of SQL queries used to retrieve data. Runtime variables can be defined to prompt users for input values at execution time; a special frame can even be designed for this purpose. ISSUPG.RW (listing 4) gives specifications for one report in the *PC Tech Journal* application. Note the **$** preceding volume and number columns in the query: users are prompted for runtime values for these variables, and a report is generated only for the issue specified. Figure 3 shows part of the report's first page generated by the specifications.

## FIGURE 3: *Sample Report*

```
15-AUG-1987                                                          14:43:29
                              Issue Page Count Report
Volume:  3      Number:  1
 Title                                        Author(s)              Ed List
 -----                                        ------ -              -- ----
 Best of Monitors                             Charles Stuart         16    2
 Fixing a Bug in Scientific Software          Phillip Connolly        2    0
 Future Trends in COBOL                       Williams Johnson       14    2
 How to Use Fixed Disk Drives                 Allen Merrill           8    0
 Inner Workings of PL/1                       John Chan              16    6
 Interfacing to AT/370                        Alfred Burke           12    7
 Legal Implications of Pascal                 James Smith             8    0
 Manipulating BIOS                            Christopher Hagen       6    0
 Product Review: Modems                       Stanley Brown          14    7
 The State of Assembly Language               Norman Walker          10    0

                                              Issue totals:     106   24
                                                Net pages:        130
```

For advanced reports, INGRES supplies Report Writer, which has its own command language. A portion of the code that generated the report is in listing 4.

CIRCLE NO. 123 ON READER SERVICE CARD

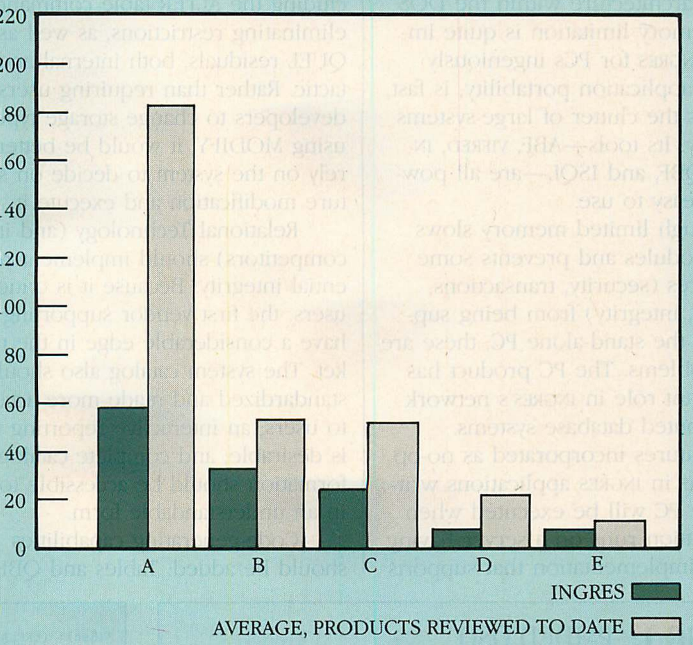
Despite its power, its preservation of set-processing by SQL queries, and its intuitive language, the Report Writer is not completely in tune with INGRES's relational productivity gains. It is not interactive, requiring that users manually lay out and position the report before using the commands to create a computerized layout. This is cumbersome, inconvenient, and unproductive and results in long specifications. The Report Writer is procedural in that it tells the system, step by step, how to format the report, rather than letting the system figure it out from an interactive visual layout.

Another difficulty with the Report Writer is that learning a third language, in addition to SQL and 4GL, is not attractive to users. Relational Technology offers an interactive Report-By-Forms (RBF) facility, which generates Report Writer code that users can customize for its non-PC implementations. It would be helpful to users if Relational Technology were to add RBF to a future release of INGRES for PCs.

INGRES offers several useful utilities. ADDINGRES loads local data managers into memory, ADDNET activates the INGRES/NET interface to load remote data managers, and RMINGRES unloads data managers. HELPR and PRINTR display and print information about a database, CREATEDB and DESTROYDB create and destroy databases, and LISTDB lists all available databases. SYSMOD modifies all system catalog tables, repacking and reclustering data pages to speed query processing. This suggests that the MODIFY command can be used with the same results on user tables. INGBATCH -sql invokes the SQL batch processor; COPYDB, COPYAPP (OUT/IN), COPYFORM, and COPYREP are used to transfer databases, applications, forms, and reports between INGRES systems. Each of these utilities can be tuned to various command line flags. The ADDINGRES, command for example, allows users to reallocate memory among various internal uses to enhance performance.

**FIGURE 4:** ***Performance Benchmarks***

| BENCHMARK TASK | TIME |
|---|---|
| A. Add 900 records to an empty database table | 58 |
| B. Index table on two fields (7 bytes) | 33 |
| C. Document and tally codes from one column | 24 |
| D. Mass change of one column (28 rows of 900) | 7 |
| E. Extract selected records to create a text file | 7 |




*All times are in seconds.*

*All benchmarks were run on an IBM PC/AT (6MHz) with 640KB memory. The test were run in an 8MB partition on a CMI 20MB disk under DOS 3.0.*

**INGRES, even with the added facilities (catalog and optimizer) provided by relational data managers, performs much better than the average data manager. This indicates that the benefits of relational features outweigh the overhead involved.**

## IMMENSE POTENTIAL

*PC Tech Journal*'s sample application, designed to test the full power of PC data managers, barely scratches the surface of the power of INGRES 5.0. A **mainmnu** frame was developed for the application, with options triggering menus for QUERIES, REPORTS, BENCHMARKS, and TABLES maintenance. The application is a combination of QBF and user frames and procedures. Some user frames are menu frames (like the main menu), which are used to control the flow of frames in the application.

Developing the application in INGRES was easy with the exception of table maintenance. The difficulty there is due to the lack of referential integrity, a common omission by all relational vendors. The table maintenance part of the application requires handling of multiple tables; in the case of article data, for example, simultaneous maintenance of the Art_auth and Articles tables must be designed with validation look-ups on the Authors and Issues tables. The burden on the developer is not coding this in INGRES/4GL, but in figuring out all possible table relationships that can affect data consistency at update. Support of referential integrity at the data manager level would eliminate this effort, speed up development, and avoid likely errors. It would also mean that integrity constraints need not be repeated in multiple queries and applications, an unproductive redundancy with negative ramifications when constraints change.

The results of *PC Tech Journal*'s benchmarks are shown in figure 3. In all tests, INGRES performed substantially better than the average of all data managers tested to date. These results are impressive, considering that relational data managers such as INGRES are taking over programming functions from developers and are performing functions in the background (catalog use and maintenance and query optimization), which nonrelational and relational-like systems do not have. Despite this overhead, INGRES performs better than products that do not have these facilities. To achieve equivalent performance, other

relational data managers might require tuning by users or developers, involving them in complex physical access/storage management that is foreign to most PC users. INGRES also could be tuned for better performance than the benchmarks show.

INGRES for PCs has combined mainframe capabilities with an excellent menu-driven interface that PC users have come to expect. Its effective use of the PC architecture within the DOS 640KB memory limitation is quite impressive. INGRES for PCs ingeniously preserves application portability, is fast, and avoids the clutter of large-systems complexity. Its tools—ABF, VIFRED, INGRES/4GL, QBF, and ISQL—are all powerful and easy to use.

Although limited memory slows loading modules and prevents some SQL features (security, transactions, journaling, integrity) from being supported on the stand-alone PC, these are minor problems. The PC product has an important role in INGRES's network and distributed database systems.

All features incorporated as no-op instructions in INGRES applications written on the PC will be executed when the application runs on a server having an INGRES implementation that supports them. Relational Technology easily could add the remaining SQL features because a sound architecture is already in place. Given the coming larger memory of OS/2 and the speed of 80386-based machines, INGRES for PCs has immense potential.

Some minor adjustments could make this excellent product even better. For example, the INGRES/SQL should be complete and standardized by including the ALTER table command and eliminating restrictions, as well as the QUEL residuals, both internal and syntactic. Rather than requiring users and developers to change storage types using MODIFY, it would be better to rely on the system to decide on structure modification and execute it.

Relational Technology (and its competitors) should implement referential integrity. Because it is critical for users, the first vendor supporting it will have a considerable edge in the market. The system catalog also should be standardized and made more accessible to users; an interactive reporting facility is desirable; and complete catalog information should be accessible to users in an understandable form.

Code-generating capabilities should be added: Tables and QBF could generate SQL and 4GL code that users could customize, giving INGRES (with one stroke) application-generation capabilities.

The full SQL-based INGRES 6.0, with improved memory management, is slated for release in the second quarter of 1988. Relational Technology has a reputation for technical excellence and reliability; most of the recommended adjustments are relatively easy to add, and the product's existing relational foundation is strong.

Relational data managers and SQL are gradually imposing themselves on the market. Because of this, serious application developers who desire connectivity, portability, and high performance, and who need a powerful, easy-to-use development tool with an insured growth path cannot afford to ignore INGRES on the PC. Relational Technology's new focus on distributed database technology further emphasizes the need for a complete SQL-based relational data manager for the PC.

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## LISTING 1: PAIDED.OSQ

```
INITIALIZE =
    BEGIN
       MODE QUERY;
    END
'COST' (EXPLANATION= 'Cost of Editorial Page') =
    BEGIN
       paided = SELECT volume, number
                FROM issues
                WHERE QUALIFICATION (volume = volume, number = number)
          cost = SELECT paid, pages, edpay = paid/pages
                FROM v_paided
                WHERE volume = :volume AND number = :number
       BEGIN
          'NEXT' (EXPLANATION = 'Next Issue') =
             BEGIN
                NEXT;
             END
          'QUIT' (EXPLANATION = 'End Query') =
             BEGIN
                ENDLOOP;
             END
       END;
       CLEAR FIELD ALL;
    END
'CODE' (EXPLANATION= 'View Code - this Frame') =
    BEGIN
       HELPFILE '4GL Code - Fees per Editorial Page'
                '\ingres\abf\pctj\paided.osq';
    END
'DOS' (EXPLANATION= 'DOS Shell') =
    BEGIN
       CALL SYSTEM;
    END
'QUERIES' (EXPLANATION= 'Queries Menu') =
    BEGIN
       RETURN;
    END
'[Esc]' (EXPLANATION= 'Menu Key') =
    BEGIN
       RESUME MENU;
    END
```

## LISTING 2: ARTAUTH.OSQ

```
PROCEDURE cr_art () =
    BEGIN
       CREATE TABLE articles (volume INTEGER1,
                              number INTEGER1,
                              category VCHAR(17),
                              dept VCHAR(21),
                              title VCHAR(60),
                              comm VCHAR(1),
                              received DATE,
                              epages INTEGER1,
                              lpages INTEGER1,
                              payment MONEY,
                              bonus MONEY)
      COPY TABLE articles (volume=VCHAR(0)COMMA,
                           number=VCHAR(0)COMMA,
                           category=VCHAR(0)COMMA,
                           dept=VCHAR(0)COMMA,
                           title=VCHAR(0)COMMA,
                           comm=VCHAR(0)COMMA,
                           received=VCHAR(0)COMMA,
                           epages=VCHAR(0)COMMA,
                           lpages=VCHAR(0)COMMA,
                           payment=VCHAR(0)COMMA,
                           bonus=VCHAR (0)NL)
      FROM "a:articles.con"

      MODIFY articles TO CBTREE UNIQUE ON volume, number, title

      CREATE TABLE art_auth (volume INTEGER1,
                             number INTEGER1,
                             title VCHAR(60),
                             lname VCHAR(18),
                             fname VCHAR(12))
```

```
  COPY TABLE art_auth (volume=VCHAR(0)COMMA,
                      number=VCHAR(0)COMMA,
                      title=VCHAR(0)COMMA,
                      lname=VCHAR(0)COMMA,
                      fname=VCHAR (0)NL)
  FROM "a:art_auth.con"

  MODIFY art_auth TO CBTREE UNIQUE ON volume, number, title, lname, fname
END
```

## LISTING 3: ARTTBL.OSQ

```
'CREATE' (EXPLANATION= 'Create, Load and Index Tables') =
    BEGIN
       CALLPROC cr_art;
    END
'MAINTAIN' (EXPLANATION= 'Maintain Tables') =
    BEGIN
       CALLFRAME artmnt;
    END
'CODE' (EXPLANATION= 'View Code - this Frame') =
    BEGIN
       HELPFILE '4GL Code - Articles Tables Menu'
              '\ingres\abf\pctj\arttbl.osq';
    END
'DOS' (EXPLANATION= 'DOS Shell') =
    BEGIN
       CALL SYSTEM;
    END
'TABLES' (EXPLANATION= 'Tables Menu') =
    BEGIN
       RETURN;
    END
'[Esc]' (EXPLANATION= 'Menu Key') =
    BEGIN
       RESUME MENU;
    END
```

## LISTING 4: ISSUPG.RW

```
.NAME pgcount
.QUERY  SELECT *
        FROM v_rep1
.SORT volume, number, title, epages, lpages
.PAGELENGTH 66
.ULCHARACTER "-"
.HEADER REPORT
   .FORMAT title (B60)
   .FORMAT name (C30)
   .FORMAT epages (B4)
   .FORMAT lpages (B4)

   .POSITION title (1,60)
   .POSITION name (62,30)
   .POSITION epages (94,4)
   .POSITION lpages (99,4)

   .NEWLINE 2
   .LEFT
   .PRINT CURRENT_DATE
   .RIGHT
   .PRINT CURRENT_TIME
   .NEWLINE
   .CENTER
   .PRINT "Issue Page Count Report"
.NEWLINE 2
.FOOTER REPORT
   .NEWLINE
   .TAB 77 .PRINT "Report totals:"
   .TAB +3 .PRINT CUMULATIVE SUMU(epages) (+F4.0)
   .TAB +1 .PRINT CUMULATIVE SUMU(lpages) (+f4.0)
   .NEWLINE
   .TAB 81 .PRINT "Net pages:"
   .TAB +6 .PRINT (SUMU(epages)+SUMU(lpages)) (+F4.0)
   .NEWLINE
.HEADER PAGE
   .NEWLINE 2
   .LEFT
   .PRINT CURRENT_DATE
   .RIGHT
   .PRINT CURRENT_TIME
   .NEWLINE
   .CENTER
   .PRINT "Issue Page Count Report"
   .NEWLINE 2
   .IF NOT BREAK (number) .THEN
.LEFT
   .PRINT "Volume: ",volume (I2)
   .TAB 17 .PRINT "Number: "number (I2), " (cont.)"
   .NEWLINE
   .ELSE
.NEWLINE
   .ENDIF
   .FOOTER PAGE
     .IF NOT BREAK (number) .THEN
   .CENTER .PRINT "* This issue continued on following page *"
          .NEWLINE 2
     .ENDIF
     .CENTER .PRINT PAGE_NUMBER
   .HEADER NUMBER
     .NEED 5
     .NEWLINE
     .LEFT
     .PRINT "Volume: ",volume (I2)
     .TAB 17 .PRINT "number: "number (I2)
     .NEWLINE
     .UNDERLINE
       .WITHIN title
   .TOP
   .LINESTART
   .PRINT "Title"
       .END WITHIN
       .WITHIN name
   .TOP
   .LINESTART
   .PRINT "Author(s)"
       .END WITHIN
       .WITHIN epages
   .TOP
   .LINESTART
   .PRINT "Ed" (+C4)
       .END WITHIN
       .WITHIN lpages
   .TOP
   .LINESTART
   .PRINT "List" (+C4)
       .END WITHIN
       .NEWLINE
     .NOUNDERLINE
   .FOOTER number
     .NEWLINE
     .TAB 78 .PRINT "Issue totals:"
     .TAB +3 .PRINT SUMU(epages) (+F4.0)
     .TAB +1 .PRINT SUMU(lpages) (+F4.0)
     .NEWLINE
     .TAB 81 .PRINT "Net pages:"
     .TAB +6 .PRINT (SUMU(epages)+SUMU(lpages)) (+F4.0)
     .NEWLINE
   .HEADER TITLE
       .TFORMAT title (C60)
       .TFORMAT epages (F4.0)
       .TFORMAT lpages (F4.0)
   .DETAIL
       .NEED 2
       .WITHIN title
   .LINESTART
   .PRINT title
       .END WITHIN
       .WITHIN name
   .LINESTART
   .PRINT name
       .END WITHIN
       .WITHIN epages
   .LINESTART
   .PRINT epages
      .END WITHIN
      .WITHIN lpages
   .LINESTART
   .PRINT lpages
      .END WITHIN
      .NEWLINE
```

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Clipper has the power to save and restore multiple screens to and from memory variables. You can also create overlays, call object modules compiled in other languages, and create function libraries to link with your applications. Power and flexibility make it the #1 dBASE compiler. List: **$695**, PC Brand: **$375**.

## McMAX *From Nantucket*
### *Like dBASE for the Macintosh*

McMax™ is like running dBASE on the Macintosh. It combines an easy-to-use menu-driven ASSIST mode using the Mac interface, an interactive command mode like dBASE at the dot prompt, and an application programming language fully compatible with dBase III. It gives you the power to create dBASE language applications on the Macintosh and transfer back and forth to the IBM® world. McMax accommodates up to 16 million records, 32,000 characters per record, 255 characters per field, and up to 32 files open concurrently. No copy protection. List: **$295**, PC Brand: **Call**.

## dBASE AT THE SPEED OF C
### *dBx Translates dBASE Applications to C*

You dBASE™ programmers know what an expressive and readable language dBASE is. It's a very comfortable development environment. But the price is debased performance. Even compiled dBASE doesn't offer the speed that some users require these days. The kind of speed offered by software written in the C language. The answer is dBx™.

dBx translates dBASE to C. It offers you a major competitive advantage over the next dBASE programmer: Keep writing in dBASE. Take every application all the way to completion. Then use dBx to translate them top to bottom to C!

Other advantages: C is portable, even to other operating systems like UNIX/Xenix™. To the Macintosh or Amiga. dBx gives your applications a passport to places dBASE cannot go.

Has its own file manager for single user, but links to major C file managers—c-tree and dBC—for compatibility with dBASE files or multi-user support. We have everything you'll need, including good advice.

| | List: | PC Brand: |
|---|---|---|
| dBx | **$ 350** | **$ 299** |
| with Library Source | **$ 550** | **$ 469** |
| with Full Source Code | **$1500** | **$1282** |

## dBC *Identical dBASE III Plus Files Using C*

dBC™ is a series of C libraries from Lattice which creates, accesses and updates files identical to those of dBASE itself. So dBASE can read and update the files too.

What for? It means both C and dBASE applications can operate on the same data bases interchangably. It means C programmers can interface with the big market of dBASE users out there, yet side-step the dBASE language. It means dBASE applications can now be linked to the universe of C libraries and tools to add windows, graphics, statistical analysis, all the things dBASE cannot do. It means the speed and power of C to impress clients accustomed to dBASE!

dBC's functions parallel all dBASE's file handling commands, many decomposed to permit direct data manipulation. Our versions of dBC mimic file formats for dBASE II and III and now dBASE III Plus makes your programs network ready!... as many stations as a network allows. Hands-off mode handles record and file locking and unlocking automatically. Close in functions give you direct lock/unlock control.

Supports all four memory models.
dBASE II, III...List: **$250**, Ours: **$195**.
dBASE III Plus...List: **$750**, Ours: **$595**.
*Pay double and you get source too!*

## SUPER SOURCE
### *Aldebaran's Source Print*

Author Alan Simpson writes "the best overall debugging technique is to draw lines to connect all the IF and DO WHILEs etc. with their ENDIFs and ENDDOs. Then use a pencil to"—Well, thanks, Alan, but we'll use Source Print instead. It draws those vertical lines to connect the beginnings and endings of structure in a vivid display of your program's organization. It can print your programs with page numbers, headings, line numbers, indent automatically, throw in a table of contents and cross-reference index. "Occasionally a utility comes along that makes a programmer's life much easier. Source Print is such a program" says *PC Magazine*. List: **$75, Ours: $60.**

### ...add Tree Diagrammer

Tree Diagrammer prints an organization chart of your program's structure showing the hierarchy of function, procedure, and subroutine calls. Shows at a glance what routines call each other for clearer debugging. Every shop should have this important documentation tool. List: **$55**, Ours: **$45.**

### *30-DAY MONEY-BACK GUARANTEE*

*We refund the purchase price of any product returned within 30 days in entirely resalable condition.* **You can even try out many programs themselves.** *Ask your salesperson for details. There's just nothing stopping your buying from PC Brand.*

## C-WORTHY INTERFACE LIBRARY
**NEW VERSION!**

The C-Worthy™ Interface Library wraps an entire user interface around your application. Its full power can be summoned by only a few high level calls. Sound exaggerated? A single function call can set up a complete text editor in a screen window. Recently acquired by Solution System, over 600 pages of Documentation, Turbo and Quick C version and a complete Interface Library have been added.

- High level calls pop menus and scrollable choice lists to the screen, restoring the background when dismissed.
- Windowing facilities open portholes of up to screen size for viewing virtual screens larger than the physical screen.
- Full context-sensitive help screen management takes over these chores and error messages. Automatic routines interrupt with pageable text windows explaining what to do next.

Novell found it "played a key role and accelerated development" in making its NetWare™ utilities easier for users. Ingenious demo: call for it.

| Ask for: | List: | PC Brand: |
|---|---|---|
| C-Worthy | **$195** | **Call** |
| with Forms Library | **$295** | **Call** |

## BASTOC *BASIC Into C*

For a trifling price, BASTOC™ moves truckloads of BASIC code over to C. It's a translator which takes in Microsoft Extended BASIC and emits pure K&R C for Microsoft or Lattice. Structures even convoluted BASIC code. Optimized to dramatically reduce execution time. Dynamic string allocation ends BASIC's catatonic halts for garbage collection. Huge worksaver. List: **$495**, Us: **$399**.

## BTRIEVE *B-tree File Manager Plus Add Ons*

If networks are on your horizon, betting your future on Btrieve as the one file manager for your C, Pascal, BASIC, and COBOL projects looks like a smart move. Reason? Novell bought Btrieve's creator.

Btrieve's function library takes complete charge of all file creation, indexing, reading, writing, insertion, deletion, space recapture, forward and backward searching. Finds any key in a million in four or less accesses. Files may have up to 24 indexes; fixed record length to 4090 characters; variable length to 64k; indexes up to 255 characters; files of 4 billion bytes.

List: **$245**, Us: **$195**. Network Version List: **$595**, Ours Only: **$465**. Ask about Xtrieve for Btrieve file inquiry, Rtrieve for report writing. For any network that supports the MS-DOS 3.1 file sharing function.

## PANEL PLUS
### *Library Source Code Gives It Complete Portability*

There are no end of tools for screen design and data entry, but none quite like Panel Plus. Design a screen under program control, use Panel's utility to "run" and test it field by field, then pass it to Panel's code generator which delivers C source code. Options style the code to your compiler's liking, and you can of course do what you like to the source afterward. The code calls Panel Plus's function library, but now *the library comes in source*, so everything produced is highly portable. Not like other screen managers delivered as object libraries and which leave *you* to write the detailed code.

Panel Plus will operate in graphics mode via interfaces to graphics products it supports and can utilize the EGA's 43-line screen. Low-level I/O functions adapt it to various keyboards, screens, operating systems.

Panel's newest incarnation has every imaginable feature. A single screen design can have 1000 fields stacked as visual overlays up to 127 levels deep or as pop-ups. Groups of fields can be moved between levels. Screens can be output as compilable code or stored on disk for loading at run-time. Each field can be boxed, colored, multi-row, word-wrapped, and scrolled horizontally and vertically if larger than its on-screen view aperture. It can be assigned its own help and error message, can be told to accept certain characters, or to match a picture, and to check data after entry—proper dates, number ranges, etc.—using Panel's or your own validation routines. You can add your routines to Panel's test utility because even it comes as source. Fields are accessed in any order and control reverts to your application program after each field for choice of action.

For past Panelists, the new version has smaller and faster field and screen functions, tighter granularity, and an enhanced, reworked library. Major tool for the serious developer. List: **$495**, PC Brand: **$395**.

## POLYTRON VERSION CONTROL
### *Source Code Control for Any Language*

*PVCS* allows programmers, project managers, librarians and system administrators to control the proliferation of revisions and versions of source code in software systems. Independent programmers, the leading software publishers and LAN companies, and hundreds of Fortune 1000 companies rely on PVCS to store and retrieve multiple revisions of text. It maintains a complete history of revisions as an "audit trail", generates status reports, and uses intelligent "difference detection" to minimize disk space for each new version.

On Corporate and Network PVCS simultaneous changes to a module are merged into a single new version. If changes conflict, the user is notified. The "Logfiles" used to track changes are interchangeable between any PVCS product.

Corporate PVCS is for multiple programmers. It includes "branching" to maintain code when programs evolve on multiple paths. Personal PVCS offers most of the power and flexibility of corporate PVCS, but excludes multiple programmer features. Network PVCS is the Corporate version for LANs. File locking and security levels can be tailored to each project.

*PolyMake* Still using a prehistoric Make? Step up to PolyMake, the most popular and powerful Make utility. Most flexible macros of any Make. Now integrated with PVCS and PolyLibrarian for faster performance and precise configuration management.

| Ask for: | List | PC Brand: |
|---|---|---|
| Personal PVCS | **$149** | **$109** |
| Corporate PVCS | **$395** | **$309** |
| Network PVCS | **Call** | **Call** |
| PolyMake | **$149** | **$109** |

**Payment:** We honor MasterCard, Visa, American Express (no surcharge), checks in advance, or funds wired to PC Brand, c/o Chemical Bank, 126 East 86 St., New York, Account 034-016058. COD (U.S. only) for cash, money order, certified check (no fee). NY State, add sales tax. Purchase orders accepted from larger corporations and institutions at our discretion if you agree to net 30 days plus 2% a month late penalty thereafter.
**Shipping & Handling:** U.S.: UPS Surface: 1st product $6, each add'l $3. UPS 2nd Day Air: 1st product $10, each add'l $4.50. UPS Next Day Air or Federal Express 1-2 Day Air: 1st product $18, each add'l $6. FedEx Next Day 10 AM: 1st product $28, each add'l $7. International: Charges vary by destination and carrier. $10 per shipping container for export forms. Air parcel post at your risk beyond collected insurable amount.

*For Orders or Literature, Call Us at....*

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That's (800) 722-7263. In NY State call (212) 242-3600
PC Brand, 150 5th Ave., New York, N.Y. 10011-4311
Telex: 667962 (SOFT COMM NYK)



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# PROGRAMMING PRODUCTIVITY TOOLS

## BRIEF *Is Anything But.* *A Whopper of an Editor*

With a name that belies its thoroughness, Brief™ has every feature you've ever contemplated for your editor-in-chief. Text in multiple buffers is scrolled through one or more windows you open, close, resize. A text buffer may be called to different windows to view two areas at once. A change in one changes both. Text blocks may be marked for printing, writing to files, movement to scrap buffers for cut and paste into other buffers, with as many "undo" levels as you want.

Brief has text search abilities rivaling "grep", with wildcards for matching and indifference to intervening characters.

If you use Lattice, C86™, or Wizard, and have 320k, you can compile your C program without ever leaving Brief. It finds the lines with errors, and marches you through the text for repairs.

Parts of Brief were written with its own easy-reading Lisp-like macro language which has structure, conditionals, loops. "Simply the best text editor you can buy", - Dvorak *Infoworld*. (Needs 192k.) List: **$195**, PC Brand: **Call.**

## C-TREE & R-TREE

*B-Tree File Manager Now Has Report Generator*

| | List: | Ours: | Combined: |
|---|---|---|---|
| c-tree: | **$395** | **$329** | **$541** |
| r-tree: | **$295** | **$245** | |

**c-tree:** The only major b-tree file manager with network support in the standard low-cost version, c-tree™ gives you record-locking routines for DOS 3.1/3.2, UNIX and XENIX, and it even comes in C source code, yet there are no royalties. Source sticks to K&R, so C-tree is portable. Tests in many environments prove it.

Permits any number of keys for a data file—alpha, numeric, even floating point. Handles files with varied record lengths, multiple keys in one index file. Both high level and decomposed functions. It's the works.

**r-tree:** Adds the ability to produce ad hoc reports from files maintained by c-tree (v. 4.1 and up). Link a file description to the r-tree™ library, and use any text editor to write report scripts with no further C coding. Reports can access data in several files, select on criteria, join findings into new logical records, sort them, calculate new fields and columns, tabulate by control breaks. Comes in source, same portability as c-tree, and fits any compiler.

## WINDOWS for DATA

FIRST PRIZE!

*M'Soft Windows Compatible*

"Only one package can be easily recommended" said *Computer Language* (June '87) reviewing nine window and data entry products for C. Complete field level functions specify prompt string, field length, data type, screen location, picture, target variable, entry rules, help messages, even functions to call for validation once data keyed in.

Windows for C is a subset. No data entry but all windowing functions. Unlimited windows can be made either to pop up or permanently overwrite the screen, scroll and highlight lists vertically and horizontally. Specify Compiler. Windows for Data: List **$295**, Ours **$259**. Windows for C: List **$195**, Here **$149**.

## ESSENTIAL C UTILITY LIBRARY

*400 Functions, 30c Each*

You've probably seen the speed and power of Essential's C function library without knowing it. Software greats have been using it for some time to give today's top products pizazz and panache.

Now grown to 400 functions Essential produces pop-up menus, saves and restores screens and windows to disk or memory in as little as 1/10th second, and claims the fastest video output available. Library has 50 business graphics functions, 40 string handlers, 28 functions for printers, 18 for mice, 11 for time and date, DOS interface functions for disk error trapping, directory and file creation and management, lots more. Everything in source, including sample programs. We have versions with pre-built libraries for the well-known C compilers, and a source code librarian is supplied for rolling your own.

| | List: | PC Brand: |
|---|---|---|
| C Utility Library | **$185** | **$119** |
| Essential Graphics | **$250** | **$183** |
| Essential Communications | **$185** | **$125** |
| with Breakout Debugger | **$250** | **$189** |

# Shopping List for the Power Workbench

| | LIST | US |
|---|---|---|
| **ARITY PRODUCTS** | | |
| **Arity Combination Package** | 1095 | 979 |
| **Expert System Development Pkg** | 295 | 229 |
| **File Interchange Toolkit** | 50 | 44 |
| **PROLOG Compiler & Interpreter** | 650 | 569 |
| **Screen Design Toolkit** | 50 | 44 |
| **SQL Development Package** | 295 | 229 |
| **Arity PROLOG Interpreter** | 295 | 229 |
| **Arity Standard Prolog** | 95 | 77 |
| **AI-EXPERT SYSTEMS** | | |
| **EXSYS** *Development Software by EXSYS* | 395 | 309 |
| **EXSYS Runtime System** | 600 | 469 |
| **Insight 2+** *by Level Five Research* | 485 | 379 |
| **AI-LISP LANGUAGE** | | |
| **IQCLISP** *by Integral Quality* | 300 | Call |
| **IQLISP** *by Integral Quality* | 270 | Call |
| **Microsoft LISP** *Common LISP* | 250 | 199 |
| **TransLISP** *from Solution Systems* | 95 | Call |
| **TransLISP PLUS** *from Solution Systems* | 195 | Call |
| **AI-PROLOG LANGUAGE** | | |
| **APT** *Active Prolog Tutor from Solution Sys.* | 65 | Call |
| **Prolog-86** *from Solution Systems* | 125 | Call |
| **Prolog-86 Plus** *from Solution Systems* | 250 | Call |
| **Turbo PROLOG** *by Borland Int'l* | 100 | 63 |
| **Turbo PROLOG Toolbox** *by Borland Int'l* | 100 | 64 |
| **ASSEMBLERS & DEBUGGERS** | | |
| **Advanced Trace-86** *Morgan Debugger* | 175 | 119 |
| **C-Sprite Debugger** *by Lattice, source level* | 175 | 139 |
| **Microsoft Macro Assembler** *with Utilities* | 150 | 109 |
| **PASM86** *by Phoenix, Macro Assembler* | 195 | 138 |
| **Periscope I Debugger**...*The Periscope Co.* | 345 | 289 |
| **Periscope II** *with NMI Breakout Switch* | 175 | 139 |
| **Periscope II-X** *software only* | 145 | 105 |
| **Periscope III** *with Advanced Board...New* | Call | Call |
| **BASIC LANGUAGE** | | |
| **Microsoft BASIC Interpreter** *for XENIX* | 350 | 295 |
| **Microsoft QuickBASIC Compiler**...*3.0* | 99 | 79 |
| **BORLAND PRODUCTS** | | |
| **Reflex & Reflex Workshop** | 200 | 129 |
| **Reflex** *Data Base System* | 150 | 89 |
| **Reflex Workshop** | 70 | 45 |
| **Turbo Basic**...*New* | 100 | 64 |
| **Turbo C Compiler**...*New* | 100 | 64 |
| **Turbo Lightning** | 100 | 64 |
| **Turbo Pascal & Tutor**...*New* | 125 | 85 |
| **Turbo Pascal with 8087 & BCD** | 100 | 64 |
| **Turbo PROLOG Compiler** | 100 | 63 |
| **Turbo PROLOG Toolbox** | 100 | 64 |
| **Turbo Tutor** | 40 | 28 |
| **C COMPILERS** | | |
| **C86 PLUS** *by Computer Innovations...New* | 497 | 397 |
| **Lattice C Compiler** *from Lattice* | 500 | 299 |
| **Let's C Compiler** *by Mark Williams* | 75 | 55 |
| *with CSD Source Level Debugger* | 125 | 90 |
| **MWC-86: Mark Williams C Development** | 495 | 369 |
| **Microsoft C Compiler**...*4.0* | 450 | 295 |
| **Turbo C Compiler** *by Borland...New* | 100 | 64 |
| **C INTERPRETERS** | | |
| **C-Terp** *by Gimpel Software* | 300 | 249 |
| **Instant C** *by Rational Systems* | 500 | 395 |
| **Interactive-C** *by IMPACC with debugging* | 249 | 219 |
| **RUN/C Professional** *from Lifeboat* | 250 | 185 |
| **COMMUNICATIONS** | | |
| **Asynch Manager** *by Blaise, for C or Pascal* | 175 | 135 |
| **Greenleaf Communications** *by Greenleaf* | 185 | 139 |
| **C UTILITY LIBRARIES** | | |
| **Blaise C TOOLS PLUS/5.0** | 129 | 99 |
| **Blaise Turbo C TOOLS** | 129 | 99 |
| **Blaise C TOOLS PLUS** | 175 | 135 |
| **C Food Smorgasbord** *by Lattice* | 150 | 109 |

| | LIST | US |
|---|---|---|
| **C Utility Library** *by Essential, 300 functions* | 185 | 119 |
| **Greenleaf Functions** *by Greenleaf Software* | 185 | 139 |
| **COBOL LANGUAGE** | | |
| **RM/COBOL**...*see Ryan-McFarland Prod.* | | |
| **Microsoft COBOL Compiler** | 700 | 499 |
| **Microsoft COBOL Compiler** *for XENIX* | 995 | 795 |
| **Micro Focus COBOL**...*see Micro Focus Prod.* | | |
| **dBASE SUPPORT** | | |
| **BRIEF/dBRIEF**...*Brief for DBASE III* | 275 | Call |
| **CLIPPER**...*from Nantucket* | 695 | 375 |
| **McMAX**...*dBASE for MAC from Nantucket* | 295 | Call |
| **Foxbase+**...*from Fox Software* | 395 | Call |
| **Foxbase+ Multi-User** | 595 | Call |
| **QUICKCODE PLUS**...*Fox + Geller* | 295 | 170 |
| **QUICKREPORT**...*Fox + Geller* | 295 | 170 |
| **QUICKENTRY**...*Fox + Geller* | Call | Call |
| **The UI Programmer**...*Wallsoft* | 295 | 244 |
| **The Documentor**...*Wallsoft* | 295 | 244 |
| **dFlow**...*Wallsoft* | 149 | 124 |
| **dBx**..*dBASE to C Translator by DESKTOP AI* | 350 | 299 |
| *with Library Source Code* | 550 | 469 |
| *with Full Source Code* | 1500 | 1282 |
| **dBC**...*from Lattice...maintains DBASE files* | 250 | 195 |
| *with source* | 500 | 390 |
| **dBC III Plus**...*supports multi-user DBASE* | 750 | 595 |
| *with source* | 1500 | 1185 |
| **DEVELOPMENT TOOLS** | | |
| **BASTOC** *by JMI, convert BASIC to C* | 495 | 399 |
| **BASIC-C** *BASIC's functions added to C* | 175 | 139 |
| **Report Option** *Softcraft Btrieve Report Gen.* | 145 | 128 |
| **Xtrieve** *Softcraft Query Utility for Btrieve* | 245 | 220 |
| **Code Sifter** *Profiler by David Smith* | 119 | 89 |
| **Dan Bricklin's Demo Program** *Prototyper* | 75 | 69 |
| **LMK** *from Lattice, "make" like UNIX* | 195 | 149 |
| **Microsoft Window Development Toolkit** | 500 | 365 |
| **ESSENTIAL PRODUCTS** | | |
| **C Utility Library** | 185 | 119 |
| **Essential Graphics** | 250 | 183 |
| **Essential Comm Library** | 185 | 125 |
| *with Breakout Debugger* | 250 | 189 |
| **FILE MANAGERS** | | |
| **Btrieve** *by Softcraft, no royalties* | 250 | 195 |
| **Btrieve Network** *by Softcraft* | 595 | 465 |
| **C-Tree** *by FairCom - no royalties, source* | 395 | 329 |
| **R-Tree** *by FairCom-Report Generator* | 295 | 245 |
| **C-Tree & R-Tree Combo** *by FairCom* | 650 | 541 |
| **dbVista** *single user DBMS by Raima* | 195 | 139 |
| **dbVista** *multi-user DBMS* | 495 | 399 |
| **Opt-Tech Sort** *Can sort Btrieve files* | 149 | 105 |
| **FORTRAN LANGUAGE** | | |
| **RM/FORTRAN** *by Ryan McFarland* | 595 | 499 |
| **The Automated Programmer**...*by KGK* | 995 | 949 |
| **FORTRAN Libraries**...*by Alpha Computer* | 70 | 45 |
| **Microsoft FORTRAN** *Links w/Microsoft C* | 450 | 281 |
| **Microsoft FORTRAN** *for XENIX* | 695 | 546 |
| **Scientific Subroutine Package** *by Alpha* | 295 | 239 |
| **GRAPHICS** | | |
| **Essential Graphics** *Essential, no royalties* | 250 | 183 |
| **GSS Graphics Development Toolkit** | 495 | 375 |
| **GSS Kernel System** *by Graphic Software* | 495 | 375 |
| **GSS Metafile Interpreter** | 295 | 235 |
| **Halo** *by Media Cybernetics* | 300 | 219 |
| *with* **Dr. Halo II** | 440 | 299 |
| **Halo for Microsoft** *includes all fonts* | 595 | 434 |
| **MICRO FOCUS PRODUCTS** | | |
| **Micro Focus Level II COBOL** *w/Animator* | 495 | 395 |
| **Level II COBOL** | 349 | 279 |
| **Level II Animator** | 195 | 155 |
| **Micro Focus Personal COBOL** | 149 | 99 |
| **Forms-2** | 295 | 235 |

| | LIST | US |
|---|---|---|
| **MODULA-2 LANGUAGE** | | |
| **MODULA-2 Compiler Pack** *by LOGITECH* | 99 | 79 |
| **MODULA-2 Development Pack** | 249 | 199 |
| **MODULA-2 ROM Pkg & Cross RT Debugger** | 299 | 239 |
| **MODULA-2 Toolkit** | 169 | 139 |
| **MODULA-2 Window Pkg** *by LOGITECH* | 49 | 39 |
| **OTHER LANGUAGES & UTILITIES** | | |
| **Source Print**...*source code formatter* | 75 | 60 |
| **Tree Diagrammer**..*source code diagrammer* | 55 | 45 |
| **Microsoft MuMath** *includes MuSimp* | 300 | 199 |
| **Microsoft Pascal Compiler** *Links w/M'soft C.* | 300 | 199 |
| **Microsoft Pascal Compiler** *for XENIX* | 695 | 546 |
| **Turbo Power Tools+** *by Blaise* | 100 | 67 |
| **Advantage C++** *by Lifeboat Assoc.* | 495 | 435 |
| **PHOENIX PRODUCTS** | | |
| **PASM86** *Macro Assembler* | 195 | 138 |
| **PDisk** *Phoenix's new disk manager* | 195 | 138 |
| **Pfantasy Pac** *six products...New Price* | 995 | 655 |
| **PFinish** *EXE performance analyzer* | 395 | 278 |
| **Pfix86 Plus** *Symbolic Debugger* | 395 | 259 |
| **PforCe** *vast library* | 395 | 235 |
| **PforCe++**...*Function Library for C++* | 395 | 278 |
| **Plink86 Plus** *Utilizes memory for overlays* | 495 | 326 |
| **Pmaker** *like UNIX "make"* | 125 | 89 |
| **Pmate** *with Macros* | 195 | 138 |
| **Pre-C** *UNIX "lint"-alike* | 295 | 195 |
| **PTel** *Binary File Communicator* | 195 | 138 |
| **POLYTRON PRODUCTS** | | |
| **PVCS Corporate**...*Source Code Control Syst.* | 395 | 309 |
| **PVCS Personal** | 149 | 109 |
| **PVCS Network** | Call | Call |
| **PolyMake** *Complete Make Utility* | 149 | 109 |
| **PolyLibrarian** *Library Manager* | 99 | 73 |
| **PolyLibrarian II** *Library Manaer* | 149 | 109 |
| **PolyShell** *UNIX-like Command Shell* | 149 | 109 |
| **PolyXREF** *Complete Cross Ref Utility* | 219 | 169 |
| **PolyXREF** *One language only* | 129 | 99 |
| **PolyBoost** *The Software Accelerator* | 80 | 64 |
| **PolyDesk III** *3rd Generation Desktop Org* | 99 | 73 |
| **PolyDesk III** *Add On Tools* | Call | Call |
| **RYAN-McFARLAND PRODUCTS** | | |
| **RM/FORTRAN**...*2.4 New* | 595 | 499 |
| **RM/FORTRAN**...*UNIX or XENIX* | 750 | 599 |
| **RM/COBOL**...*DOS* | 950 | 799 |
| **RM/COBOL**...*UNIX or XENIX* | 1250 | 999 |
| **RM/COBOL 85**...*ANSI 85 COBOL* | 1250 | 995 |
| **RM/SCREEN**...*for COBOL 85* | 395 | 335 |
| **RM/NET +5**...*COBOL & COBOL 85 Network* | 300 | 249 |
| **SCREEN DESIGN** | | |
| **Curses** *by Lattice, UNIX screen designer* | 125 | 99 |
| *with Source* | 250 | 199 |
| **Greenleaf Data Windows**...*New* | 225 | 169 |
| *with source* | 395 | 297 |
| **Panel Plus** *by Round Hill, no royalties..New* | 495 | 395 |
| **View Manager for C** *by Blaise* | 275 | 199 |
| **Vitamin C** *by Creative Programming* | 225 | 198 |
| **VC Screen** *by Creative Programming* | 100 | 81 |
| **Windows for C** *Vermont Creative Software* | 195 | 149 |
| **Windows for Data** *includes Windows for C* | 295 | 259 |
| **ZView** *Data Management Consultants* | 295 | 259 |
| **TEXT EDITORS** | | |
| **Brief** *from Solution Systems* | 195 | Call |
| **Condor Editor** *by Condor* | 130 | 118 |
| **Edix** *by Emerging Tech...Multi-screen* | 195 | 159 |
| **Epsilon** *by Lugaru Software, like EMACS* | 195 | 149 |
| **FirsTime** *by Spruce Technology, C syntax* | 295 | 229 |
| **Kedit** *by Mansfield, similar to Xedit* | 125 | 99 |
| **LSE, the Lattice Screen Editor** *Multi Wind.* | 125 | 100 |
| **Vedit** *by Compuview* | 150 | 99 |
| **Vedit Plus** *by Compuview* | 185 | 129 |

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# PRICED TO SAVE, SHIPPED FAST!!!

## HALO
### *Graphics Tools for Software Developers*

When choosing your graphics tools for software development, performance is crucial. The best proof of HALO's superior performance is in the number of Independent Software Vendors (ISVs) that develop and distribute HALO-based applications. Over 190 ISVs selected HALO because: HALO out performs the rest; *HALO* is easier to program and *shortens time-to-market*; HALO is complete with over 190 functions; 17 programming languages; and HALO supports a wider range of devices—over 110.

Since 1981 HALO has been the industry standard library of graphic subroutines for the PC. HALO has an installed base of 60,000+ end users and hundreds of site licenses.

A single copy of HALO includes all device drivers, your choice of one compiler binding, LearnHALO (an interactive tutorial), free 800 # technical support, and the license to use HALO on one machine. Flexible, practical licensing terms are available for ISVs and "Sites."

| | List: | PC Brand: |
|---|---|---|
| Halo | **$300** | **$219** |
| with Dr. Halo III | **$440** | **$299** |
| Halo for Microsoft | **$595** | **$434** |

## GREENLEAF LIBRARIES
### *Functions*

C source, assembler source, and binary libraries of 225 functions for many compilers. Emphasizes tight functional groupings to minimize loading code which your application may never use. Manual's 250 pages help select functions, as do demos, bulletin board.

A sampling: *DOS:* extensions for file and directory manipulation. *Screen:* select mode, page, monochrome or color, palette; cursor shape, positioning; clearing and scrolling; pixel get and put. *Strings:* efficient operations to add, delete, sort string pointers for top speed. *Other:* graphics primitives, keyboard status, function key assignment, time/date, read registers, get memory size, peek and poke.

Specify Compiler. List: **$185**, Here: **$139**.

### *Communications*

Communicate with other users or remote data bases by asynchronous communications built right into your C programs! Over 120 functions *and demo programs in both C and assembler source code* set up separate transmit and receive ring buffers for up to 16 simultaneous channels. Interrupt driven so you can halt an incoming record, display it, file it, let the user edit it, then continue. Goodbye separate communications software.

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## PHOENIX POWER
## PFORCE
### *Pfunction Pfestival*

***Phantasmagoria!** The list price of Phoenix's Pfantasy Pac—Pmate, Plink 86 Plus, Pfix 86 Plus, Pmaker, Pfinish, and Ptel combined—is now $995. Our price is better still,* ***$655!***

The ultimate integrated C library, offering everything from low level functions for hardware access to complete b-tree database management. Along the way are fundamentals for string manipulation, time/date calculations, field and screen editing, but also four styles of menus (Lotus included), windowing, background tasking, DOS interfaces, directory management, even interrupt-driven communications.

Beyond tools for application development are programmer utilities for disk library management, archiving and compilation. Design emphasizes objects so characteristics of windows, databases, records and fields can be established outside functions.

One large collection means consistent instructions, single index. PforCeTM has tutorials, examples, quick reference, and on-line help.

Everything in source, no royalties, all memory models of Lattice, M'soft.

List: **$395**, PC Brand: **$235**.

## PRE-C *Pick the Lint from Your Program*

Pre-CTM is like UNIX's "lint". It finds problems your compiler won't. Problems that a debugger will have trouble figuring out.

Compilers work with one module at a time. They don't see other modules which only meet at link time. Pre-C looks at *all segments of your program at once* and reports inter-module calamities: conflicting data type declarations; parameter lists in function calls which disagree with the functions themselves; machine-dependent expressions which inhibit portability, obsolete usage, casts with suspect conversions, variables never used, functions never called.

Adheres to Unix System III standard for portability. List: **$295**, From Us: **$195**.

## PLINK86 PLUS *Cached Overlays Maximize Memory Use*

Plink86TM shoehorns large programs into small machines by swapping program segments in from disk. Because modules share memory, a 512k program could run in a 128k machine, for example. But Plink86 is smarter than that: if it finds itself in a larger machine, it moves into leftover memory whatever program overlays will fit. Overlays now swap at memory speed not disk speed. Can automatically restore a displaced overlay to which a subsequently called overlay must now return, and can assign library modules either to the root segment or to overlay areas. Long indispensable to serious developers. Ask for:

List: **$495**. Us: **$326**.

## GSS GRAPHICS SYSTEM
### *Leave the Device Driving to GSS*

GSSTM has reconfigured two components of its comprehensive graphics tools to conform with the ANSI Computer Graphics Interface (CGI) standard.

At the heart of the system is the Development Toolkit which contains all language interfaces and device drivers for keyboards, mice, joysticks, tablets, printers, plotters, cameras, and more. Drivers house management of vector graphics (plotters) and bitmaps used by raster input devices (scanners) to insulate the application program from concern for device idiosyncracy. No one else has implemented CGI that way. It means your programming remains generic; just switch drivers and the same program will drive a different device.

GSS KernelTM conforms to level 2b of ANSI's Graphical Kernel System (GKS) and contains all its needed drivers and language bindings. Kernel has macro level tools to draw and color an object, store the sequential instructions, and recreate the object on its own, as well as segment it, transform it, etc. So powerful, a single command may represent several score lower level statements.

Kernal has the tools for graph and chart generation and their captioning; hand it apples and oranges, say "pie", and it bakes the numbers into a digestible display for screen or plotters.

Kernel can convert the images it creates to ANSI Computer Graphics Metafiles (CGMs), a tokenized standard for storing every form of graphic image as data. The Metafile Interpreter reads the contents of a CGM and interprets it with full CGI capability for recreation on various devices.

Quality software? IBM thinks so. They sell the GSS series under their own label.

Unit royalties and annual fees have been instituted for redistribution. Needs 256k.

| Ask for: | List | PC Brand: |
|---|---|---|
| CGI Dvlpmt Toolkit | **$495** | **$375** |
| Kernel System | **$495** | **$375** |
| Kernal for IBM RT | **$795** | **$645** |
| Metafile Interpreter | **$295** | **$235** |

## BLAISE
## C TOOLS PLUS/5.0

C TOOLS PLUS/5.0 from Blaise Computing Inc. helps you to quickly build professional applications using the full power of Microsoft C 5.0 and QuickC. Now you can concentrate on program creativity by having full control over DOS, menus, interrupt service routines, memory resident programs, fast direct video access; windows; printer and keyboard control, and more!

Blaise Computing's attention to detail, like the use of full function prototyping, cleanly organized header files, and a comprehensive, fully-indexed manual, makes C TOOLS PLUS/5.0 the choice for experienced developers as well as newcomers to C.

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| Turbo C TOOLS | **129** | **99** |
| C ASYNCH MANAGER | **175** | **135** |
| Turbo POWER TOOLS | **99** | **75** |
| Turbo ASYNCH PLUS | **99** | **75** |

## The AUTOMATED PROGRAMMER
### *Enter Mathematical Notation Directly*

A programming system for numerical computation that enables a computer to recognize and process mathematical, engineering, and scientific specifications. Using the Two-dimensional (2D) Text Editor, input computational formulas directly using conventional mathematical notation (e.g., integral, summation, numerator-over-denominator division, matrix inverse, dot and vector products, etc.) and technical English. The description of the problem solution (program) is expressed at such a high level that it approaches the ideal of an executable specification, i.e., for many problems, *the specification is the program.* A correct program can be achieved many times faster than by current programming methods. Verification and debugging are often reduced to proof reading—"If it looks right, it is right."

The Automatic Programmer translates 2D programs into a target language, permitting easy interfacing with existing program libraries. The currently available target language is FORTRAN.

Computational results may be embedded in complex 2D text and graphic "IMAGE" formats using intuitively obvious (WYSIWYG) control.

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## MICROSOFT C 4.0
### *The Keeper of the Technology Takes Over*

It bundles a source debugger and a "make", and sports a "huge" memory model permitting single data objects larger than 64k, but what's really impressive about Microsoft C are the benchmarks reported in Dr. Dobb's. Microsoft runs away from a field of 17 winning 11 of 27 benchmarks.

The CodeViewTM debugger uses windows to show everything on one screen: source alongside disassembled object, variables, stack and registers. Drop down windows obviate learning of commands. "A source-level debugger that puts the rest to shame" said Dobb's.

Microsoft C has five memory models for code and data, plus non-library support for another thirteen, and boasts alternate math packages for speed versus accuracy, with or without 8087/80287 chips.

Both linker and library manager are part of the package, as is the "make", which knows how to rebuild any size project by compiling only elements which have changed.

It is reportedly used by Lotus, Ashton-Tate and, fittingly, Microsoft itself to develop Windows. Dobb's calls it "the best MS-DOS C development environment value today [for] virtually any kind of program conceivable." 320k suggested.

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CIRCLE NO. 233 ON READER SERVICE CARD

COVER SUITE:
SPEAKING SQL

DATA MANAGERS AS DEVELOPMENT TOOLS

# Managing Databases, Mainframe-Style

DAVE BROWNING
and HUGO BLASDEL

ORACLE, which has long been a major player in the mainframe-based data management world, now has migrated to the PC, taking with it almost all mainframe capabilities that are available on ORACLE mainframe versions, as well as the efficiency of nonprocedural, set-level processing of true relational systems.

Like Relational Technology's INGRES 5.0 (reviewed in "Relational Power, PC Ease," Fabian Pascal, this issue, p. 78), Professional ORACLE uses Structured Query Language (SQL) and provides better performance than average data managers for the PC. ORACLE provides more powerful capabilities than INGRES, but requires more memory and an 80286 or 80386 processor to do so. Whereas the strength of INGRES lies in its easy-to-use, menu-driven user interface, ORACLE's interface is still largely command driven.

Professional ORACLE is distinguished by the following characteristics:

- Its kernel has most capabilities of the mainframe version, including transaction processing, space allocation, security controls, and integrity.
- SQL-based relational capabilities and an optimizer for performance.
- A mainframe, rather than PC, orientation that gives database administrators (DBAs) tremendous options for optimizing performance. This orientation gives DBAs the ability to rely on defaults. Without defaults, users need to act as DBAs (as in mainframes) and become involved in space allocation, setting parameters, and so on.
- Nonmenu driven capabilities, except for SQL*Forms, a tool for creating forms. Unlike most PC products, all other features in Professional ORACLE must be accessed via commands entered from DOS.

This review of Professional ORACLE evaluates elements common to all data managers as well as those specific to relational systems. The basis of evaluation is the same as that used to judge INGRES. As shown in table 1, ORACLE meets 7 of the 12 rules developed by E. F. Codd for defining fully relational data managers (as described in the sidebar, "What is Relational?," in "Lingua Franca for Databases," Richard Finkelstein, this issue, p. 52.

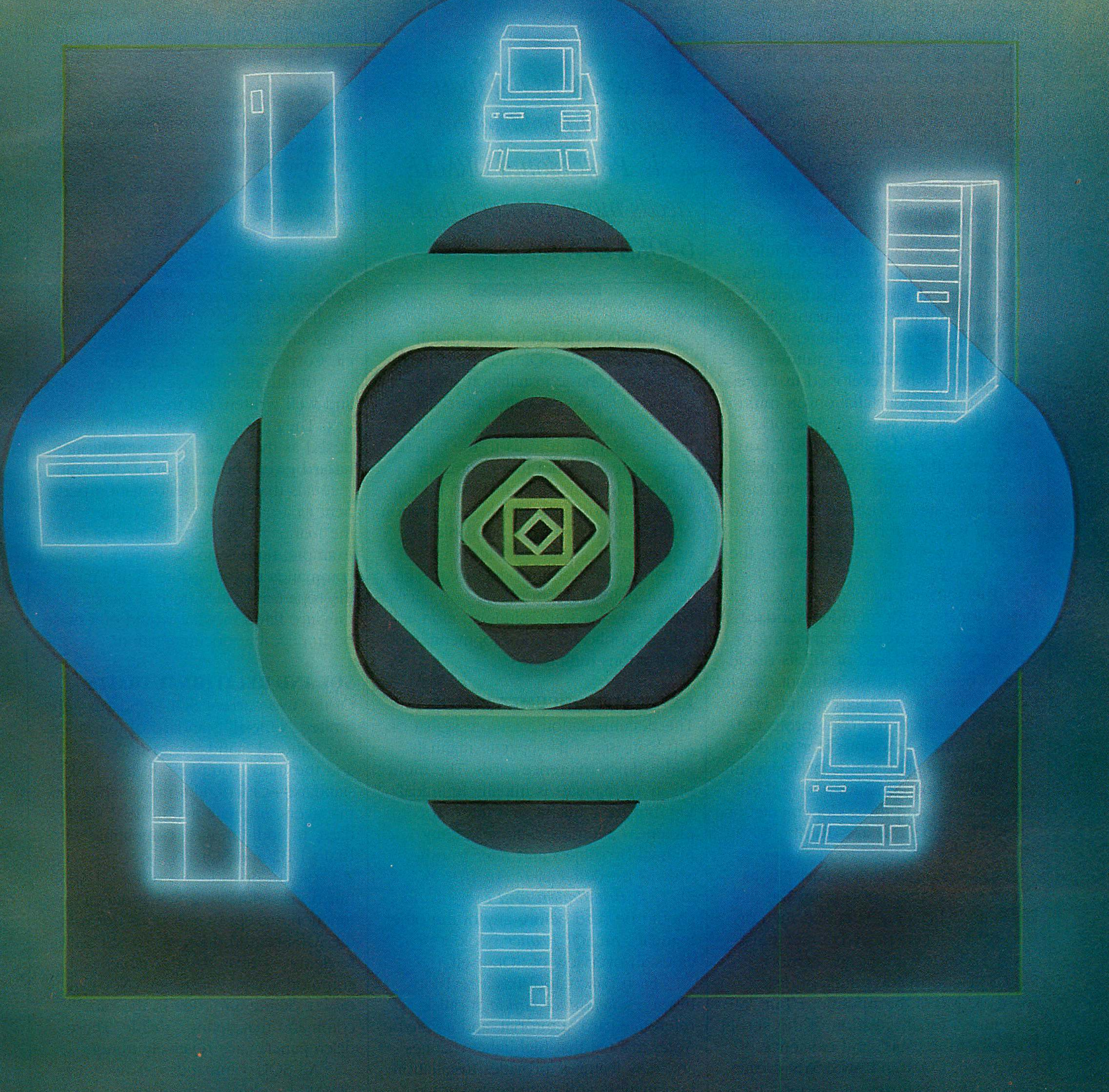
## OPERATIONAL OVERVIEW

Professional ORACLE is a single-user program that runs on a PC/AT, a PS/2 Model 50, 60, or 80, or an 80386-based machine operating under OS/2 or DOS 3.1 or later; or it runs on the Compaq Deskpro 386 under DOS. It requires 640KB of regular RAM, 896KB or more of extended RAM, at least 7.5MB of free space on a hard disk, and a color or monochrome display and adapter. Equivalent functionality across all machines is achieved by using the C language; 95 percent of code is common to all implementations.

ORACLE includes the relational data manager engine, called the ORACLE kernel, and most development and production tools (SQL*Plus, SQL*Forms, SQL*Report, SQL*Calc, and Pro*C) available on larger ORACLE implementations. It can function as a development system for ORACLE applications to be run on mainframes, minicomputers, or on Networkstation ORACLE connected to a mainframe or LANserver ORACLE (the foundation of ORACLE's database server system). Many tools provided in release 4.0 have been modernized.

ILLUSTRATION • ANDY LEVINE

*The mainframe passes on its powerful capabilities to the PC through Professional ORACLE 5.1, requiring more than DOS's 640KB in order to run, but delivering powerful data management.*



To execute its database engine and application tools, Professional ORACLE needs more memory than the 640KB DOS limit so it is equipped with a memory-management controller. The ORACLE kernel is loaded to extended memory from disk when ORACLE is started. An executive module, the Protected Mode Executive (PME), loads as a terminate-and-stay-resident (TSR) program using 80KB in lower memory and executes the kernel in extended memory using the CPU's protected mode. Application and development tools execute as typical DOS programs in the remainder of the DOS addressable memory and communicate with the database kernel through the resident PME. This approach sets the stage for easy integration of a mature product into the multitasking OS/2 environment when that operating system becomes available. Professional ORACLE uses a math coprocessor if available.

Although Professional ORACLE is a stand-alone version, all ORACLE multiuser features, such as read-consistency, file and record locking, deadlock detection and elimination, and transaction processing, are fully implemented and documented. This allows multiuser applications to be developed in Professional ORACLE for installation on multiuser systems. No waits or deadlocks occur in the stand-alone version, but the locks will fire, as needed, if applications written on the PC are run on multiuser systems. This multiuser functionality is characteristic of all ORACLE versions, not simply an addition to the single-user PC version.

The software licence provided with Professional ORACLE includes standard restrictions on reverse engineering or copyright removal and prohibits disclosure of benchmark tests without Oracle Corporation's written agreement. Professional ORACLE is not copy protected. The program is warranted for 90 days.

Professional ORACLE is packaged in a 22-pound box containing two plastic diskette cases and three documentation cases. The programs are distributed on nineteen 360KB diskettes.

Installation proceeds basically as documented. After backing up the diskettes and checking extended memory (the cold boot memory counter must reach 1,536KB without any errors), PREP.BAT checks for sufficient disk space (1.2MB is the minimum, but 7MB is required for installation of the kernel plus all of the tools) and existence of COMMAND.COM and ANSI.SYS, creates the ORACLE directories, and selects the appropriate video driver.

Professional ORACLE users must include a path to \ORACLE5\BIN and set CONFIG to \ORACLE5\CONFIG.ORA in AUTOEXEC.BAT. COMMAND.COM must be in one of the directories listed in the DOS PATH statement. If there is insufficient space in the environment, SHELL=C:\COMMAND.COM /P /E:320 must be added to the CONFIG.SYS file. This potential difficulty was not mentioned in the ORACLE installation procedure, nor was the work-around. The CONFIG.SYS file must have at least 40 files and 16 buffers, BREAK=ON, and DEVICE=ANSI.SYS.

*To execute its database engine and application tools, Professional ORACLE needs more memory than 640KB DOS limit.*

ORAINST.BAT is used to install desired software. SQL*Plus must be installed first. Basic installation support is provided for 30 days after purchase and includes software update service and five telephone calls to the ORACLE support team. A hot-line option for additional phone calls also can be purchased. In addition, Oracle Corporation offers training, which is available in numerous major cities, with courses ranging from free introductory design seminars to in-depth courses on database design, system administration, advanced applications development, and applications tuning.

## EXTENSIVE DOCUMENTATION

The documentation for Professional ORACLE consists of 24 separate manuals and 4 quick-reference cards. The multiplicity of manuals is initially intimidating, but their quality and internal completeness allow users to select any manual by subject and refer to others only as needed. *ORACLE For IBM PC/MS-DOS Installation and User's Guide* should be read before any of the other manuals. An *SQL Primer* booklet provides an overview of SQL itself.

Each ORACLE tool has a revision history, a *Reference Guide*, a quick-reference card, a tutorial, and a *Release Notes* manual that highlights changes and new features, provides installation information, and documents known bugs and work-arounds for each program. ORACLE's documentation of these last two elements is a professional touch not found in many PC programs.

SQL*Forms has an operator's guide and a quick reference card for application users; some of the tools also have introduction or *Quick Tour* manuals. The *Quick Tour* manuals are excellent hands-on overviews that work in conjunction with the tutorials to present a keystroke-by-keystroke introduction, then pick up the pace and build on material already presented.

The *Database Administrator's Guide* and *Pro*C Manuals* are the most technically detailed, assuming a significant level of reader expertise, whereas an *SQL*Calc Manual* assumes the user has no spreadsheet familiarity. A *Forms Designer's Reference* manual is more like an extended tutorial, which seems an appropriate way to present a highly interactive design tool. Except for the *PC Guide*, all documentation is common to all ORACLE installations, which is an impressive statement of compatibility. An 84-page *ORACLE Value Added Relicensors Product and Services Catalog* lists tools, vertical market applications, and services available from Oracle Corporation and other vendors.

ORACLE manuals are well organized and well written, but they are not perfect. They are not as thoroughly indexed as they could be, a significant hazard given the number of different manuals that contain information pertinent to a particular topic. Neither are the manuals free of trivial errors; for example, figures do not always match commands they illustrate. While these discrepancies cause no real damage, they are flaws in what would otherwise be impeccable documentation.

## SQL AND RELATIONAL TRAITS

Of the two current SQL standards—the limited "official" standard of the American National Standards Institute (ANSI) and the more complete ad hoc IBM standard—ORACLE, like many other data managers, implements the IBM standard. In addition, it is compatible with IBM's DB2 and SQL/DS.

ORACLE provides all required ANSI functions delineating SQL syntax and function, except two. It does not use the ANSI-required key word SCHEMA to denote a related set of tables with common access constraints. Nor can ORACLE define an index in the same command that defines a table. These discrepancies are relatively minor.

All SQL commands can be run in ORACLE. In addition, two fields in a table can be connected in an SQL tree-struc-

## ORACLE VITAL STATISTICS

**Professional ORACLE 5.1**
*Oracle Corporation*
*20 Davis Drive*
*Belmont, CA 94002*
*415/598-8000*
CIRCLE 344 ON READER SERVICE CARD

**Product description.** Professional ORACLE is the implementation of the ORACLE relational data manager on AT-class machines for development purposes. Professional ORACLE contains a single-user data manager kernel and several tools for system development.

**IBM PC environment.** Professional ORACLE requires an AT, a PS/2 model 50 or above, or an 80386-based machine operating under OS/2 or DOS 3.1 or later; or it runs on the Compaq Deskpro 386 under DOS. It requires 640KB of regular RAM, 896KB or more of extended RAM, at least 7.5MB of free hard-disk space, and a color or monochrome display and adapter.

**Network support.** An optional SQL*Net module allows Professional ORACLE to access remote ORACLE databases over networks or communication lines. The Networkstation ORACLE and LANserver ORACLE companion products, expected for 80286- and 80386-based machines in the fourth quarter of 1987, provide multiuser data management functionality, currently for DECnet protocols and MicroVAX servers.

**Copy protection.** Not copy protected.

**Documentation.** More than 20 pounds of professional documentation in 24 manuals contained in 3 slipcase/slantcase boxes. Tutorial, reference, installation, and user manuals are provided for system components and tools.

**User interface.** SQL*Plus gives interactive SQL access to data; SQL*Calc gives spreadsheet manipulation of data accessed from the database. Other programs such as SQL*QMX and Easy*SQL will be ported to the PC soon.

**Capacity.** Data storage capacity is limited only by available disk space. Relational data tables can contain up to 254 columns with a maximum of 126,495 characters in a table row. The number of rows and number of tables in a database are unlimited.

**Application development facilities.** SQL*Forms is a fourth-generation forms development tool, Pro*C provides an SQL interface for C language programs, and SQL*Report provides report-generation capabilities. An optional module, Pro*COBOL, provides COBOL interface to SQL. Other tools such as data dictionary design tools are available.

**Security.** Full data security is implemented through the SQL GRANT and REVOKE commands.

**Data integrity.** Transaction processing with COMMIT and ROLLBACK, before image journaling, and automatic rollback of incomplete transactions after system crash provide data integrity.

**Queries and reports.** SQL*Plus provides SQL capability for data access with basic formatting for output; SQL*Report provides full report development.

**Data compatibility.** Data in fixed-length flat files can be imported; data output formatting is accomplished with SQL command programs.

**Distribution.** Professional ORACLE is distributed directly by Oracle Corporation.

**Price.** The cost of Professional ORACLE is $1,295. This price includes the ORACLE relational data manager kernel, SQL*Calc, SQL*Forms, SQL*Plus, SQL*Report, and Pro*C.

**Support.** Installation support for 30 days is provided. Additional support is available on a fee schedule.

*—Dave Browning and Hugo Blasdel*

tured relationship by specifying the START WITH record and the CONNECT BY fields. Figure 1 shows an example of this connective capability.

ORACLE, like most relational data managers, provides language extensions beyond the minimum SQL command set. SQL*Plus includes ORACLE's language extension. It defines columns, breaks, titles, variables, and environment beyond standard SQL. Functions are provided for character, date, and numeric data manipulation.

### CREATING DATABASES

The current release of Professional ORACLE is command driven, except for SQL*Forms, in contrast to the menu-driven data managers common in the PC environment. This characteristic, along with features such as extensive space allocation and optimization capabilities, give the product a mainframe flavor. Users of the stand-alone version can act as DBAs.

For those who do not want to act as DBAs to fine tune performance, ORACLE's defaults provide excellent application performance without requiring user decisions.

Entering the word ORACLE at the DOS prompt loads the data manager kernel into memory and automatically initializes database files and a variety of buffers and operating-system-dependent parameters. Users can access any tool by entering its command name and the user name and password at the DOS prompt. ORACLE is shipped with the DBA account already set up, user name, SYSTEM, and password MANAGER. Entering SQLPLUS SYSTEM/MANAGER starts SQL*Plus.

New accounts can now be set up and developers can define a database by allocating space (or using defaults), creating tables, indexes, and views.

**Space allocation.** Because ORACLE can be implemented on a variety of mainframes, minicomputers, and microcomputers running an assortment of operating systems, ORACLE provides a several methods for controlling space (storage) allocation. This is an extremely important performance issue in the minicomputer and mainframe environment because wise management of storage space can improve application performance. The DBA (or developer at the PC level) can either set parameters to allocate space or use system defaults.

An ORACLE database consists of one or more logical partitions, each containing at least one physical file. Databases contain a SYSTEM partition (default file name, DBS.ORA). Partitions can be added to databases and physical files can be added to partitions at any time, but partitions and files cannot be dropped. Professional ORACLE uses a 1,024-byte block as its unit of storage. Table storage consists of two segments, one for data and one for indexes. Blocks are allocated to segments in groups called *extents.*

## FIGURE 1: *Tree-structured Queries*

```
Sample Data

   ENAME       EMPNO   MGR    DEPTNO
   ---------   -----   ----   ------
   SMITH       7369    7902   20
   ALLEN       7499    7698   30
   WARD        7521    7698   30
   BLASDEL     7566    7839   20
   BLAKE       7698    7839   30
   CLARK       7782    7839   10
   SCOTT       7788    7566   20
   KING        7839           10
   ADAMS       7876    7788   20
   FORD        7902    7566   20
   MILLER      7934    7782   10

SQL Syntax

   COLUMN org_chart format a21  /*an sql*plus command/*;
   SELECT lpad(' ',2 * level)||ename org_chart, level,
            empno, mgr, deptno
   FROM emp
   CONNECT BY prior empno = mgr
   START WITH ename = 'KING'

Result

   ORG_CHART          LEVEL   EMPNO   MGR    DEPTNO
   ----------------   -----   -----   -----  ------
     KING             1       7839           10
       BLASDEL        2       7566    7839   20
         SCOTT        3       7788    7566   20
           ADAMS      4       7876    7788   20
         FORD         3       7902    7566   20
           SMITH      4       7369    7902   20
       BLAKE          2       7698    7839   30
         ALLEN        3       7499    7698   30
         WARD         3       7521    7698   30
       CLARK          2       7782    7839   10
         MILLER       3       7934    7782   10
11 records selected.
```

ORACLE supports all SQL queries in ANSI standard and IBM implementation including tree-structured queries useful in organizational charts. START WITH specifies the root node; CONNECT BY specifies the relationship between nodes.

## FIGURE 2: *Check Option Sample View*

```
y CREATE VIEW my_emp
 AS SELECT ename, job, empno, mgr, deptno
 FROM emp
 WHERE deptno in
      (SELECT deptno
       FROM emp
       WHERE ename=user and job='MANAGER')
       WITH CHECK OPTION;


 GRANT select,update
 TO BLASDEL
 ON emp;


 exit


C>sqlplus blasdel/pwrd


 SELECT *
 FROM my_emp;

   ENAME     JOB       EMPNO   MGR    DEPTNO
   --------  -------   -----   ----   ------
   SMITH     CLERK     7369    7902   20
   SCOTT     ANALYST   7788    7566   20
   BLASDEL   MANAGER   7566    7839   20
   ADAMS     CLERK     7876    7788   20
   FORD      ANALYST   7902    7566   20


   UPDATE my_emp
   SET deptno=99
   WHERE ename='SMITH';

      *
   ERROR at line 3: ORA-1402:  view WITH CHECK OPTION
                               where-clause violation
```

Although user/manager Blasdel has select and update privileges, an error results if he tries to assign an employee to a different department because CHECK WITH OPTION only allows creation of rows that the view can select.

The SQL CREATE SPACE command creates named space definitions that are stored in the data dictionary tables under the view SPACES. The CREATE SPACE command specifies the initial extent size of the data segment in number of blocks (called DATAPAGES), the incremental extent size in number of blocks, and the maximum number of times ORACLE can extend the segment by incremental extents. Initial and incremental extent sizes and maximum extent allocations are also specified for the index segment (INDEXPAGES).

For data segment space, the parameter, PCTFREE, indicates the percent of allocated space to be kept free for updates, rather than for row insertions. Default values for CREATE SPACE definition are: 5 blocks for initial extents, 25 blocks for incremental extents, and 9,999 maximum extent increments. The PCTFREE parameter default value is 20. A final parameter to CREATE SPACE specifies the name of the partition to be used by the created table.

A Create Contiguous File (CCF) utility allocates and clean outs storage to be assigned to ORACLE for database use. The normal two-step process for database expansion is to run the CCF utility to create a new database file, then to use the SQL*Plus command ALTER PARTITION to add the file to one of the database partitions. If the ALTER PARTITION command file-name parameter is not specified properly, databases can be damaged. An easier alternative, the ORACLE utility program, EXPAND, adds storage to databases by performing both the CCF and the ALTER PARTITION functions with additional error checking to protect databases. EXPAND will add storage space only to the SYSTEM partition.

If users want to avoid the complexities of space allocation, default values and parameters can simplify storage allocation. By default, only the SYSTEM partition is required for a database and all tables are assigned to it; Professional ORACLE establishes the SYSTEM partition automatically as part of the installation process.

**Building tables and indexes.** Subject to disk space limitations, ORACLE can manage an unlimited number of tables in databases and an unlimited number of rows in tables. The SQL CREATE TABLES command from SQL*Plus creates tables. Storage allocation can be specified in the command as shown below or can be allowed to default:

```
CREATE TABLE tablename
   (column names data type [NULL/
      NOT NULL]
   [ [SPACE, space_definition] [PCTREE n] |
   CLUSTER cluster (column, . . . )];
```

Because no SQL command can designate a column as a primary key, the primary key is assigned by placing the

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Stephen Manes, PC Magazine

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PC BusinesSoftwareview (Rated #1)

*"...Breakthru 286 is a good value and a quality product backed by effective support."*
Dan A. Griffin
The Newsletter of the AutoCAD User's Group

*"The PCSG Breakthru 286 achieved the best performance results of the caching boards tested."*
Ted Mirecki, PC Tech Journal (Rated #1)

*"The 12-MHz Breakthru 286-12 speedup board is the fastest of those tested, but not the most expensive. On a dollar per-horsepower basis, it could be called the cheapest boost available for an XT."*
Mark Welch, InfoWorld (Rated #1)

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| | | Increase in speed over the Intel 8088 | Cost per percentage increase in speed |
|---|---|---|---|
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| ☐ Univation Dream Board | $512 | 131% | $3.91 |
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| ☐ Orchid PC-Turbo 286e | $1,195 | 321% | $3.72 |
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**But, no speedup board cuts disk access time in half**

**LIGHTNING™**

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Best of 86 review

Loads with the DOS - always ready as a background program to accelerate disk access. You do nothing - everything is automatic. Programs that frequently access the disk (hard or floppy) are made instantly up to 2 to 4 times faster. Uses a principle greatly enhanced from mainframe technology called caching. Fully exploits Above Board memory.

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We are really excited about these products. PCSG makes the unabashed statement that the BREAKTHRU 286 card represents more advanced technology than boards by Orchid, Quadram, P.C. Technologies, Phoenix...we could go on. Breakthru 286 is undisputedly the turbo board with the biggest bang for the buck. And we include FREE the $89.95 acclaimed Lightning software. Call today with your credit card or COD instructions and we will ship your card the very next day.


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**TABLE 1: *Conformity of ORACLE to Codd's Rules***

| RULE | ADHERENCE |
|---|---|
| 1. Information rule | Yes |
| 2. Guaranteed-access rule | Yes |
| 3. Systematic treatment of null-values rule | Yes |
| 4. Dynamic on-line catalog rule | Yes |
| 5. Comprehensive data sublanguage rule | Partial[a] |
| 6. View-updating rule | Partial[b] |
| 7. High-level INSERT, UPDATE, and DELETE | Yes |
| 8. Physical data independence | Yes |
| 9. Logical data independence | Partial[c] |
| 10. Integrity independence | Partial[d] |
| 11. Distribution independence | Yes |
| 12. Nonsubversion rule | Yes |

[a] *Some SQL restrictions.*
[b] *Single tables views can be updated.*
[c] *Limited updating of views.*
[d] *Referential integrity not supported.*

**According to the two reviewers, Professional ORACLE adheres fully to 7 of Codd's 12 rules and partially to 5 thus qualifying it as a truly relational data manager.**

NOT NULL attribute on a column and creating an index for the column with the UNIQUE attribute. A table can have up to 254 columns with a maximum of 126,495 characters in a row.

Professional ORACLE supports five data types for table fields: CHAR, NUMBER, DATE, LONG, RAW, or LONG RAW. CHAR data are stored as variable length strings up to 240 characters in length. NUMBER fields store numbers as high as 100 to the 64th power to 40 digits of precision; precision and scale can be specified by the table column creator. Numeric data are stored in a single, variable-length format, and key words for various number field types (such as DECIMAL, FLOAT, INTEGER, SMALLINT) implement automatic formatting. DATE fields are set to a fixed length (7 bytes) and can range from January 1, 4712 B.C. to December 31, 4712 A.D. DATE fields contain the time of day to the second.

No more than one field in a table can be of type LONG (or LONG RAW), which stores variable-length character strings to 65,536 characters in length. LONG data-type fields cannot be indexed; used in clustered tables; referenced in WHERE, GROUP BY, ORDER BY, CONNECT BY, or DISTINCT clauses; used in functions such as SUBSTR or INSTR; used in the SELECT list of nested queries; or used in expressions. Nor can LONG data-type fields appear in the SELECT list of a query block that undergoes UNION, INTERSECT, or MINUS with another query block. In addition to these restrictions, Professional ORACLE cannot enter data into LONG fields on its own; a host language program, such as C, must be used. LONG data fields, however, can be printed with formatting of line length and word wrap.

The number of indexes of a table or the number of tables or views joined in a query are not limited. Indexes are of B*-Tree structure type and are created with the CREATE INDEX command from SQL*Plus. The indexes might consist of 1 to 16 concatenated columns of a table to a maximum of 240 bytes. Indexes can be compressed to save storage space or they can be specified as noncompressed to improve query performance in cases where needed data is contained in them. This can eliminate the need for references to data tables.

**Creating views.** ORACLE also provides methods for creating and using views. A single table view is a logical table containing only selected fields from a physical table, while a multitable view is a logical table made up of two or more other tables (logical or physical) joined by common fields. Views are created using the CREATE VIEW command and are important for retrieving data from a number of tables simultaneously. In addition, according to the relational model, views that, theoretically, can be updated should be used for the simultaneous update of two or more joined tables. At present, ORACLE does not support simultaneous updating of tables through multitable views. Updating is possible for single table views except for those views with definitions that include the * shorthand notation to select all columns from a particular table. They are not automatically updated if the table is altered to add or delete columns.

## MAINFRAME-LIKE SECURITY

Security provided by Professional ORACLE on the single-user PC is as extensive as it is on the largest mainframe installation and includes GRANT, REVOKE, and a new auditing feature.

Using SQL security commands, table or view owners grant access to one or more users individually, or they grant public access. Table access rights include: ALTER, DELETE, INDEX, INSERT, UPDATE, or SELECT. Different sets of rights can be granted to different users. The UPDATE right can be restricted to a specific list of permissible table columns; and only DELETE, INSERT, SELECT, or UPDATE privileges are granted on views.

Table owners (those who control tables) grant rights to others by using the WITH GRANT OPTION. The DBA uses GRANT to create user IDs, assign passwords, and grant ORACLE-level privileges such as CONNECT (log on) and RESOURCE (create tables and so on). The ORACLE data manager maintains user privileges in tables, and SQL commands manipulate those privileges. Because SYSDATE and USER are pseudo columns of every table, access can be limited to specific users within specific time periods.

Another important part of database security is auditing; that is, tracking and monitoring successful and unsuccessful user activity, such as who accesses a database, who makes changes, when changes occurred, and other information about the event. Controlling the level of detail recorded in the audit trail is equally important. The audit feature of ORACLE, new with version 5.1, allows table owners or DBAs to use SQL commands to set up audit options.

For example, the SQL statement

```
AUDIT ALTER ON emp BY ACCESS
  WHENEVER SUCCESSFUL
```

audits successful alterations to the Emp table. In addition, system-level audit activity can be established by DBAs for classes of database operations beyond simple table modifications such as log-on/log-off activity, creating and dropping tables and other objects, and DBA actions such as GRANT/REVOKE.

Security control available in ORACLE is impressive in its scope and flexibility, but may seem excessive for the PC. But, like ORACLE's powerful storage-management capability, its security features need not be intimidating; they default to a minimum of user ID and log-on password protection and need not be accessed unless required. Security rights to tables are granted auto-

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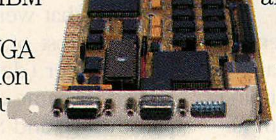

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CIRCLE NO. 204 ON READER SERVICE CARD

matically to users who create them, and audit features default to a *no audit* condition. Professional ORACLE has the identical security features provided in mainframe, minicomputer, and LAN database server versions, allowing Professional ORACLE to be used for the development of database applications to be installed on any ORACLE system.

**PARTIAL INTEGRITY**

Professional ORACLE partially supports E. F. Codd's integrity rule for relational databases, which describes three types of required integrity: entity, referential, and user defined. ORACLE supports entity integrity, which requires every record to have a unique non-null primary key, but does not support referential integrity, which addresses the concept of foreign keys where a field in one table refers to a primary key field in another table. For example, a detail table usually includes a field that contains the key to the row in a corresponding header table, such as in an order-entry system. A data manager supporting referential integrity would not permit a header table record to be deleted if any detail table records existed that referred to the header row.

User-defined integrity, which permits database designers to define data integrity constraints that are to be stored in the database catalog and administered by the data manager, is not entirely supported by Professional ORACLE. Without implementation of this constraints rule, application developers bear the burden of data validation against constraints imposed by different applications that use, data elements in question. Professional ORACLE's support of this concept is limited to implementation of the WITH CHECK OPTION of the CREATE VIEW command, which prevents data row inserts and updates that are performed through the view from creating rows that cannot be selected by the view (see figure 2).

**OPERATION OPTIMIZATION**

The optimizer offered by Professional ORACLE is similar to optimizers provided with other relational data managers. It can be operated by developers and users or can function within the program itself. ORACLE's documentation describes the behind-the-scenes optimizer functions that are not controlled by users and offers suggestions on user-activated optimization techniques that can maximize the performance of query processes. Suggestions are given on organizing SQL query command sequences for optimum performance.

Query optimization is normally performed by applications developers or DBAs for procedures that run frequently or involve complex queries. Manual optimization is supported by space allocation capabilities and by a data clustering feature.

Data clustering allows DBAs to specify that data frequently queried together be stored physically close together. In addition, key columns duplicated in tables that are frequently accessed together (such as ORDER_NO in order-entry header and detail tables) can be clustered to reduce storage space requirements. Clustering is transparent to users and applications in that data are referenced in exactly the same way whether or not they are clustered.

*The mechanism for timing query execution allows users to evaluate the efficiency of alternative query approaches by comparing timed tests.*

The SQL CREATE CLUSTER and CREATE INDEX commands indicate which physical storage and sequencing approaches can be used in order to optimize performance.

In addition to maximizing performance of physical-access parameters, logical queries can be optimized for increased productivity. For example, the HAVING and WHERE clauses are used for selection with the GROUP BY operation, and in general each can be used to develop logically equivalent SQL queries. ORACLE documentation indicates that it is more efficient to use a WHERE clause to eliminate unselected records if the comparison condition is the identity function; the less-efficient HAVING clause must be used if the condition is based on a group criteria function (such as AVG).

In order to assist the implementation of optimization, Professional ORACLE provides a mechanism for timing query execution. The mechanism allows users to evaluate the efficiency of alternative query approaches by comparing timed tests.

**PROFESSIONAL TOOLS**

Application development in Professional ORACLE is intended to be performed using fourth-generation language (4GL) tools provided, such as SQL*Forms and SQL*Report, or by embedding SQL commands in third-generation language (3GL) programs such as C. An ORACLE SQL menu-driven user-interface tool, Easy*SQL, is available on other ORACLE systems and was available in version 4.0 for the PC, but has not been released for Professional ORACLE version 5.1.

Some problems were experienced when running ORACLE tools in conjunction with other programs. The problems were caused either by a simple failure to check available memory or the PME module cannot tolerate certain other programs when executing. No similar problems were encountered when ORACLE ran in a machine with minimal device drivers and TSRs.

**SQL*Plus.** This flexible tool is an easy-to-use database interface to assist users in creating and manipulating databases. SQL*Plus can be used for formatting reports, editing, saving SQL commands, and controlling data access.

SQL*Plus includes commands beyond SQL to manipulate the interactive line editor, format reports, log on and log off of the ORACLE kernel, modify database structure, restrict data access, develop views (virtual tables) for application end users, and provide miscellaneous capabilities as help, access to host-computer services, and setting system parameter variables. In mainframe ORACLE, SQL*Plus extends SQL to support ad hoc reporting and graphics, but graphics are not yet available for the Professional ORACLE version.

SQL*Plus is an interpreted language with a quick cycle between coding and results; it is used to formulate an SQL query in simple form, execute it, and then add detail or restrict results. Both SQL*Plus and SQL commands are issued directly from the keyboard or from files created with a text editor. SQL commands entered interactively can be saved in a command file using SAVE command file name and can be run later using START command file name. However, and SQL*Plus commands that were entered interactively will be lost of the current buffer is the SQL buffer (default). If SET BUFFER is used to name a new current buffer, both SQL and SQL*Plus commands can be saved in a command file.

A line-oriented editor with buffers is furnished for modification and execution of multiline SQL statements, but users (and especially developers) might choose to install a favorite text editor for program development. An interface to DOS is also provided.

# EXTRA HELP

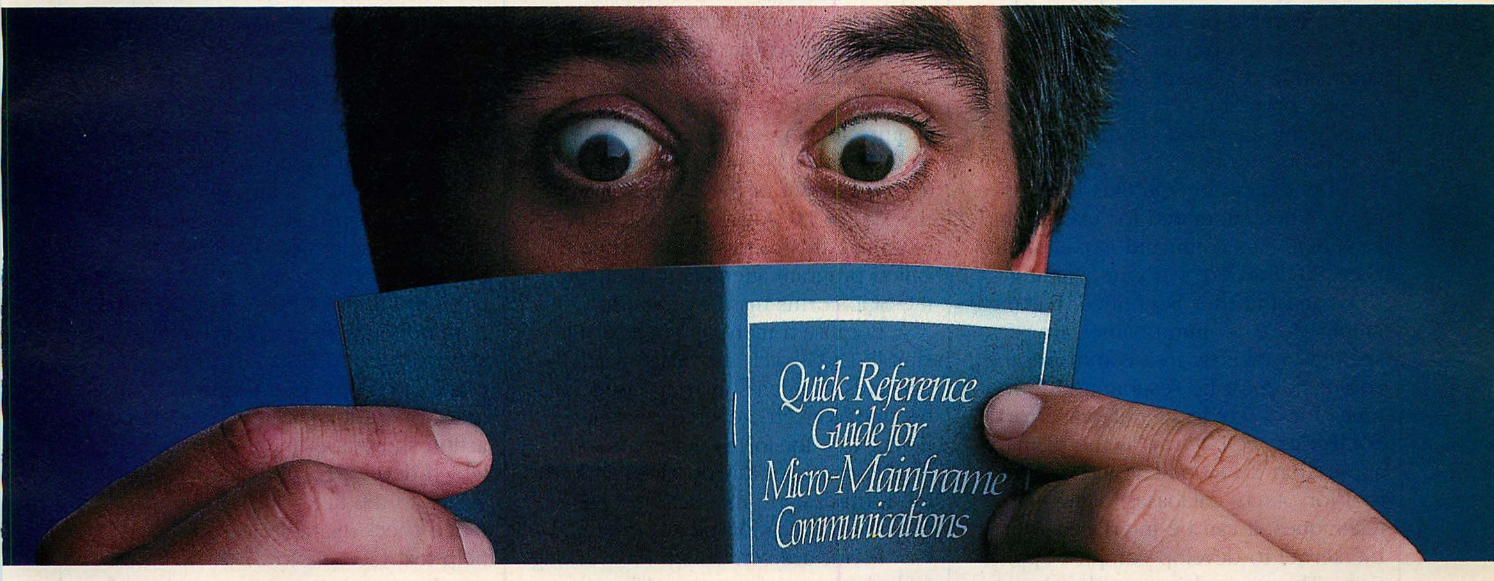


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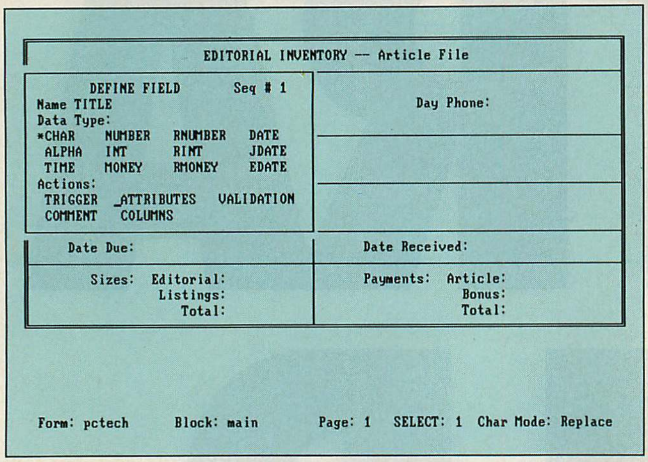
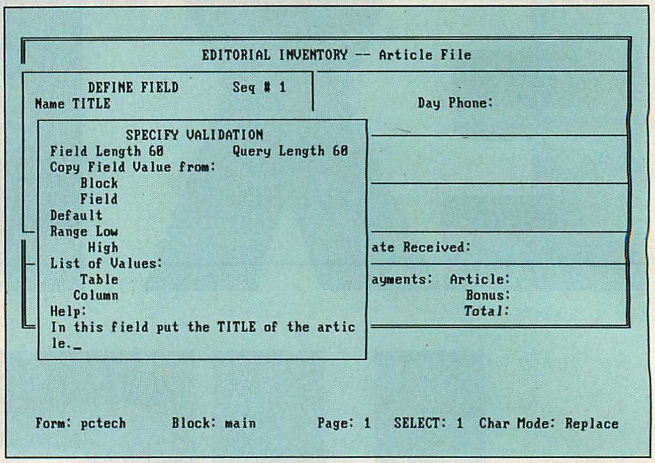
**PHOTO 1:** ***SQL*Forms Field Options***




After placing the cursor on the field and pressing the F2 function key, the name, data type, and a list of actions the developer might select are displayed on the pop-up menu.

**PHOTO 2:** ***Specifying Field Validations***




Once a field is selected, the VALIDATION action allows the developer to permit copying the value, to set defaults and ranges, to define a look-up table and to write help text.

SQL*Plus contains an abundance of elegantly implemented data-manipulation functions to interchange data types and formats. Reasonably complex reports can be written in SQL*Plus using data-manipulation functions and data-formatting commands. Output is typically presented on screen, but it can be redirected to a printer with the SPOOL command, which uses the DOS PRINT spooler program. Complex reports are usually implemented via the SQL*Report tool.

Debugging in SQL*Plus is inconvenient. When submitted for execution, each SQL*Plus command is parsed and checked; if an error occurs, parsing stops and the user is notified. For example, if four column names are spelled incorrectly in a command, the command must be resubmitted four times for ORACLE to identify all errors.

**SQL*Forms.** SQL*Forms is the primary application development and execution tool for ORACLE databases; using 4GL techniques, it can be interfaced with the kernel to develop complex applications. The menu-driven application design tool is for creation and execution of end-user data-entry, update, and query interfaces for databases.

The tool consists of several modules. The Interactive Application Designer (IAD) creates forms, which display database elements; then the Interactive Application Converter (IAC) reads the form definition and builds a .INP format file, a file common to all ORACLE implementations, that allows forms to be ported to different computers. The Interactive Application Generator (IAG) generates a system-specific version in a .FRM file that can be executed by the Interactive Application Processor (IAP), allowing use of forms without changing them. The IAD, IAC, IAG, and IAP modules are integrated through a high-level forms control menu in SQL*Forms on larger ORACLE implementations, but not on PCs.

One reason that the PC cannot use the menu to activate the IAC, IAG, and IAP modules is the lack of available memory for DOS. IAC and IAP also require logging on to databases. In single-user DOS implementations, users are logged out of the database before the IAC or IAP log-on procedure is executed; this causes failure when the called program attempts to return to the SQL*Forms master program.

Because a menu is not available, a simple DOS batch file that repeatedly executes programs in step sequence (design, convert, generate, execute) works well for forms development. SQL*Forms uses function keys in both the form-design phase and the end-user form-execution phase.

Forms are convenient for working with database information. Like a paper data-entry form, forms display data on screen. Each form is composed of unlimited pages. Data from each table included in the form are in specified areas (blocks) of the page, which can be single-record or multirecord. A form can contain several blocks, each block corresponding to a different table in the database and each one also specifying one or more records from its table for display.

To develop forms interactively, IAD is entered from the DOS prompt by typing SQLFORMS after ORACLE has been started. For simple one-table forms, default values are available. SQL*Forms automatically creates a default data-entry and query screen for a table with no special developer action required except specifying the table and executing the modules to perform the conversion and generation steps. Default forms developed in this manner are automatically multiuser.

Developers can customize forms from either blank or default screens using a series of pop-up menus, parameter data-entry windows, and screen painting. Photo 1 is an example of customizing a form. The cursor is placed on a form field; pressing F2 causes a pop-up menu to display the name, data type, and a list of possible actions for developers to choose. For example, choosing the ATTRIBUTE action displays a pop-up menu listing all attributes of a field; choosing the VALIDATE action shows a pop-up window through which developers allow copying data values to the field, and can define range checking, table look-ups, and help text (see photo 2).

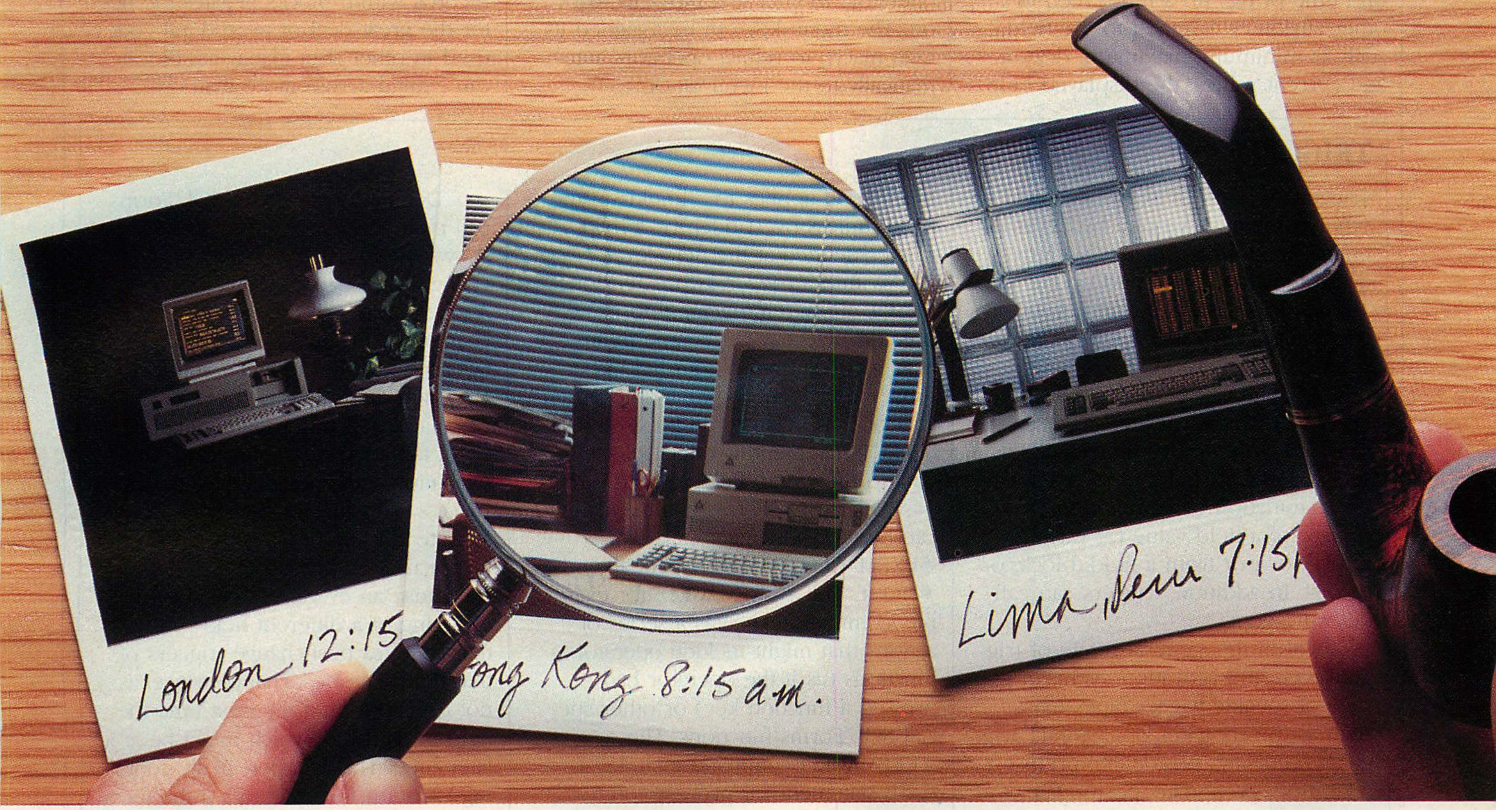
Because it is run on a variety of computer systems, SQL*Forms is simplistic in its use of the keyboard; menu options are chosen by moving the cursor to the select option rather than pressing a designated hot key.

Form fields can be assigned other attributes such as format control for data types, minimum and maximum values, default values (including database tables of multiple default values), a line of help text, or a primary key attribute to control uniqueness of data entered. The primary key attribute can be applied to more than one field; the set of fields with this attribute defines

# London, 12:15 a.m.: Inventory File Updated
# Hong Kong, 8:15 a.m.: Cash Receipt File Collected
# Lima, 7:15 p.m.: The Day's Orders Retrieved

# "Whodunnit?"

## (Case No. 52 The Mystery of CCExpress)

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the uniqueness of a record. For example, a combination of last-name, first-name fields can prevent entry of duplicate names into a table, yet allow the addition of more than one person with the same last name.

Developers can designate that the 80-character HELP text appear to users either to provide further guidance automatically when the field is entered or to assist in specific help when users press a function key (ORACLE's default is set to F10). Pressing the help key a second time brings up a full screen of other attributes assigned to the field, such as minimum, maximum, default, and current values; the displayed help text; and a list of functions, including enter, update, and query, that can be performed on the field. By using SQL*Forms, the developer can create a help database keyed to each field and help key. ORACLE's documentation shows how to set up a help screen.

Forms blocks can also be used to create menus by obtaining a field value for the choice and using the macro case statement to determine subsequent actions. An automatic menu is available from a function key, allowing operators to choose a block to work on. The menu key can be assigned its own macro to return operators automatically to the menu block.

Global variables can be defined independently of form fields and can point recursively to other variables. Variables are used for two purposes: to store temporary values and to pass values between forms and triggers. Three SQL*Form system variables (which can be read only, not written to) contain the names of the current form, block, and field.

The ability to define multirecord blocks within forms and to allow SQL*Forms to manage the scrolling of records within blocks negates the need for the great deal of procedural code used in other data managers. Blocks can extend across more than one

## TRIGGERS

Triggers are sets of SQL statements or other commands written by developers to streamline activities such as data validation, entry, and update. They fire in response to an event or user action, such as pressing a key, when a form is run.

Triggers can be defined at the field, block, or form level and can be activated by: *entry* to the trigger's associated object (field, block, or form), *query* initiation or completion, *change* of a field value (at various levels), or *exit* from a field, block, or record. In addition, triggers can call other triggers.

Within this general range of trigger levels and activation events, a variety of specific trigger types exist, such as the six types of COMMIT triggers (predelete, postdelete, preinsert, postinsert, preupdate, postupdate). The scope of a trigger depends on the level at which it is defined. For example, a field trigger defined at the block level applies to all fields in the block unless overridden by a field trigger defined at the field level.

Within a trigger, two extensions to SQL allow referencing a form field. A colon before a field name in an SQL statement refers to a field in a form rather than one in a table, and a special INTO clause can be used in a SELECT statement to cause selected data to move into fields on the form.

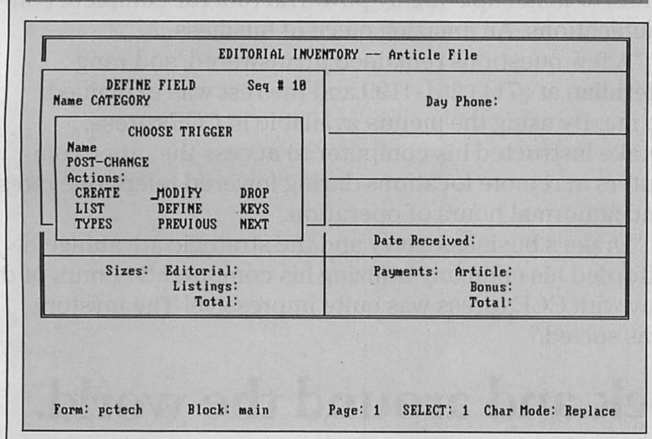
Other SQL*Forms commands that can be used in trigger steps are #EXEMACRO, #COPY, #ERASE, and #HOST. The #EXEMACRO, for example, command executes a series of actions that might include operator functions (as if the operator had pressed a function key) or other special SQL*Forms functions. The #EXEMACRO command includes a CASE statement for process control and can execute one or more of 40 available functions such as COMMIT, MOVLEFT, PAUSE, DELCHR.

Defining a trigger in SQL*Forms is a menu-driven process. Photo 1 shows the menu for defining a post-change trigger for the *category field.* A post-change trigger is driven by changing the value in the field. The SQL code for the trigger for the category field is shown in photo 2.

Each step in a trigger can succeed, fail, or generate an error; the execution sequence depends on the success or failure of each step. Events activate clusters of triggers, which in turn activate other clusters. A trigger can cause an event, such as the changing of a different field's value, that activates post-change triggers of that field. The post-change trigger is not executed until the next time the field is validated, which might be at a later time. This is a potentially confusing situation for operators if the form validation sequence is not thought out by designers.

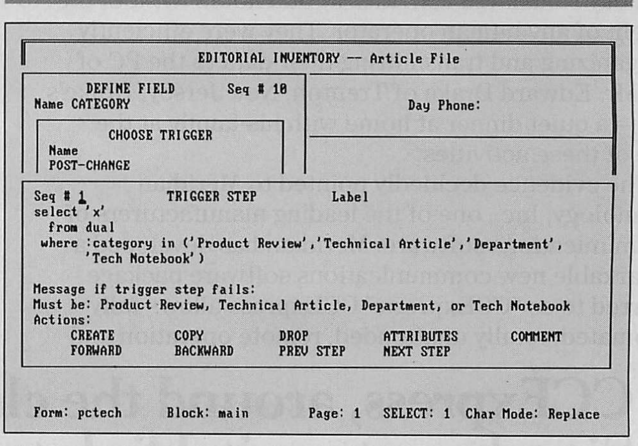
*—Dave Browning and Hugo Blasdel*

**PHOTO 1:** ***Defining a Trigger***




Selecting the TRIGGER action for the category field displays the types of triggers that can be defined for that field.

**PHOTO 2:** ***Trigger for Category Field***




The post-change trigger defined for the category field indicates the action to be taken when values are changed.

## TABLE 2: *Some Functions That Triggers Perform*

| TASKS |
|---|
| Validating data entry. |
| Protecting database integrity from operator errors. |
| Limiting operator access to specified forms or screens pertinent to assigned task. |
| Displaying data related to entered data through table lookup. |
| Comparing values between form fields. |
| Calculating and displaying calculated values. |
| Enforcing completion and coordination of transaction activities. |
| Expanding functionality of function keys. |
| Performing complex transactions. |
| Calling other forms. |
| Verifying user access to the form by identification or time of day. |

**One of the most important tools offered to developers by SQL*Forms are triggers, which are sequences of code that execute in response to some event occurring on the form. Triggers initiate a variety of important functions in an application.**

## FIGURE 3: *Application Table Creation*

```
CREATE TABLE article
   (volume char(1), inumber char(2), category char(17), dept char(21),
   title char(60), athornl char(18), authornf char(12), coauthnl char(18),
   coauthnf char(12), comish char(1), recd char(8), recdt date, edpg number(2),
   lstpg number(2), paymt number(4), bonus number(2));

CREATE TABLE author
   (lname char(18), fname char(12), addr char(20), city char(16), state char(2),
   zip number(5), work char(10), home char(10), ssn char(9), bio char(240));

CREATE TABLE issue
   (volume char(1), inumber char(2), deadline char(8), deaddate date,
   month char(9), year char(4));
```

**The Author, Articles, and Issues tables used in the *PC Tech Journal* application and benchmarks are defined using the CREATE TABLE definitions shown here.**

screen with automatic shifting from screen to screen as fields are navigated. A minor annoyance is that while SQL*Forms allows users to page down through a block, backward scrolling must be done a record at a time.

Once designed, forms can be used to manipulate databases via triggers. A trigger is a set of one or more steps executed in sequence in response to some event during the execution of a form (see "Triggers" sidebar, p. 118). Some tasks a trigger might perform are listed in table 2. A step includes one SQL or SQL*Forms command, or a user exit call (calls to traditional programs).

The nonprocedural concepts of triggers and macros provide applications developers with unlimited power to create forms for data entry and manipulation. A query-mode of forms execution allows operators to use data-entry forms to enter selection criteria for database queries, but omits trigger steps that would result in changes to the database. The ability to cause one form to call another allows very complex applications to be written. 3GL programs can also be called from within forms for special-purpose processing. Only Lattice C is supported in this environment even though Microsoft C is also supported by the Pro*C tool. Forms can exit to DOS, but cannot reenter that way due to a bug in the current release.

The fundamental nonprocedural, 4GL approach taken by ORACLE in SQL*Forms is elegant and powerful; it eliminates awkward and clumsy procedural constructs. For programmers who have never worked in a nonprocedural environment, the concept of triggers and events will require learning a new way of viewing forms development.

One significant weakness in ORACLE's overall application development capabilities is that it provides no means to document a form. Developers should be able to document their designs for application maintenance, considering how powerful and complex forms can become.

Another concern is implementation of data integrity controls in the forms tool rather than in the data manager structure. On the negative side, developers must be careful to repeat field validation each time the field is presented for update. On the positive side, operators can receive validation feedback on a field-by-field basis and implement data-correction procedures at an appropriate point in the process. Ideally, developers should be able to check data at field-entry time with ORACLE checking data integrity at transaction-commit time.

**SQL*Report.** SQL*Report develops complex, nested reports—beyond those that are within SQL*Plus's capabilities. SQL*Report requires a standard text editor to create a report control file that is composed of SQL*Report statements, user text, and report format commands (RFC). ORACLE's report generator, RPT, reads the report control file; processes SQL commands; and places the database output, user text, and report formatter (RPF) commands into an interim file. RPF processes the interim file, interpreting embedded RPF commands to integrate database output extracted by RPT with user text. The formatted output is then sent to a designated output device.

At least 30 report tables (not database tables) can be defined, with a maximum 255 columns per table, a maximum 255 input token, and no preset limits on depth of table nesting. SQL*Report places no restriction on the SQL query needed to extract data, only on the capacity of the output-formatting process. RPF assumes 66 lines per page. The documentation provides a work-around technique for shorter pages, but not longer ones.

Input requested from users by SQL*Report commands during the generation phase can be used to select data and preprogrammed report options. One unusual characteristic is that the DATE macro is expanded when reports are printed by the RPF program, rather than when data are extracted from databases by the RPT program. Report users could be misled about the age of reported data if a significant delay occurs between data extraction and report printing processes, which are controlled at the DOS level, not by Professional ORACLE.

The SQL*Report process is typical of mainframe reporting programs and should be modernized like SQL*Forms to use screen-painting techniques to specify format definitions. It is powerful and flexible, but requires learning report programming language syntax.

**SQL*Calc.** This tool provides a large spreadsheet for data display, ad hoc data manipulation, and data entry/update. SQL*Calc supports retrieval of

## FIGURE 4: *Sample SQL Query*

```
Query 1.

set space 4;

DOC
        How many pages are booked in an issue, divided into
        editorial pages and listing pages with individual
        and combined totals?  This is the simple query for
        volume 3 issue 11 as a user would type it in.
#

SELECT sum(edpg), sum(lstpg), sum(edpg+lstpg)
FROM article
GROUP BY volnum,issnum
HAVING volnum = 3 and issnum = 11;
```

```
Query 1.
DOC
  This is a slightly more elaborate version of Query 1, interactive
  and formatted for a single volume and issue, declaring column
  aliases and formats, and using ORACLE's interactive variables.
#
COLUMN cvol    format 9999 heading 'Volume';
COLUMN cnum    format 9999 heading 'Issue|Number';
COLUMN eltot   format 9999 heading 'Ed/List|Total Pages';
COLUMN clstpg  format 9999 heading 'Listing|Pages';
COLUMN cedpg   format 9999 heading 'Editorial|Pages';
SELECT volnum cvol, issnum cnum,
       sum(edpg) cedpg, sum(lstpg) clstpg, sum(edpg+lstpg) eltot
FROM article
GROUP BY volnum,issnum
HAVING volnum = &&volume_number and issnum = &&issue_number;
UNDEFINE volume_number
UNDEFINE issue_number
```

**Figure on left shows SQL query to retrieve number of issue pages, divide them into editorial/listing pages and show individual/combined totals. Figure on right shows the same query, with SQL*Plus commands used to format output.**

data from tables in response to queries and displays data in spreadsheet format. The data can be used to update, insert new rows, or delete rows in database tables. The spreadsheet interacts with the database via SQL statements entered into spreadsheet cells so that the entire database is available to users through SQL.

This tool has two drawbacks. Changes to the database applied from the spreadsheet take place slowly, one row at a time. In addition, the lack of a macro capability in the spreadsheet itself limits its usefulness as a general purpose spreadsheet program.

**Pro*C (and other Pro*languages).** Professional ORACLE Pro*C interfaces ORACLE to the C language. Pro*C is a precompiler that allows developers to embed SQL statements directly into either Microsoft or Lattice C source code.

The tool translates SQL statements into source code language for subsequent processing by the host language compiler program. It allows declaration of variables, moves data to and from the ORACLE database using SQL, and reports any status messages. Because procedural host languages process one record at a time, cursors are used to match host language record processing to SQL table processing. A cursor associated with a query is declared, opened, used, and closed. The cursor is used with the FETCH command to return query result table rows one at a time. In Pro*C, 32 cursors can be opened at the same time on the same or different tables.

In addition to Pro*C, Oracle Corporation has announced a COBOL interface. Larger ORACLE implementations also have interfaces to languages such as FORTRAN, PL/1, and Ada.

**Other Tools.** SQL*Design Dictionary, a $2,000 program that documents existing database designs, generates ORACLE database table definitions automatically. SQL*QMX, a $395 ad hoc reporting program similar to IBM's QMF, includes query-by-example (QBE), QBE-to-SQL translation, and general report-formatting capabilities.

### DETECTING ERRORS

Mechanisms in ORACLE report two general groups of errors as they occur within an application: those occurring without regard to operating system environment and those that are operating-system specific. Errors are numbered and classified into 40 groups, from "kernel access method errors" to "dictionary manipulation (recursive) errors." Individual errors are described by number, with the cause and recommended action listed.

The most frequently encountered errors in development involve SQL syntax or tool commands. SQL*Plus identifies SQL syntax errors to the faulty location in the command string and stops interpreting when the first syntax error is encountered; several iterations of correction and execution can be required to identify all errors in a single command. SQL*Report continues interpreting so that other errors can be detected. Identifying all syntax errors in structured language commands is not possible in one pass; the first error encountered affects the remainder of the command so that the parser cannot determine its validity.

Transaction processing minimizes the effect of errors on the integrity of data. Transactions can be left in an uncommitted state when Professional ORACLE encounters a program crash, whether for internal error, operating-system restart, or power outage. Upon restart, ORACLE searches for any uncommitted transactions and abnormal temporary tables; uncommitted transactions are rolled back and temporary tables are deleted to restore databases to their original states before the incomplete transactions were initiated.

Professional ORACLE differs in one important respect from other ORACLE versions in that it has no "after-image" journal that permits full restoration of databases following crashes between backups. It requires storage and processing time and expense generally too great for single-user systems.

### LOADED UTILITIES

Among Professional ORACLE's utilities is the ORACLE Data Loader (ODL), which loads data from external operating system files into previously created ORACLE tables. External file records can be fixed or variable length, but only one variable length field is allowed and it must be the last field in the record. ODL reads a control file that defines the input record fields and sets ODL parameters, such as number of records to skip, number of errors to allow before aborting, and number of records committed at one time. The control file also specifies the table to receive input records. Input record definitions identify input fields with temporary names that are used in the table-loading INSERT statement so that column arrangement need not match between input data layout and table definition.

Incoming data are validated against target column definitions, and only numeric or character data can be imported. Additional validation and conversion of dates from character to date

**FIGURE 5:** ***Sample Report Specifications***

```
Report 3.

DOC
                  list titles, vol, num, fee+bonus
                  sort by author
                  total for author by year
                  [assuming the author is paid on the
                  issue date, and coauthors are not paid]
#
break on auth page on year skip on vol on num

compute sum of paid on year

COLUMN  auth format a1 new_value ath noprint
COLUMN  vol format 99
COLUMN  num format 99
COLUMN  title format a50 word_wrapped

TTITLE  ' PAYMENTS TO ' ath skip 2
SET  pagesize 54
SET  newpage 6
SET  pause off
SET  underline on
SPOOL  output.sql

SELECT year, volnum vol, issnum num, title, paymt+bonus paid,
       authornl||', '||authornf auth
FROM article a, issue i
WHERE i.volume  = a.volume
  AND i.inumber = a.issnum and authornl like 'C%'
ORDER BY authornl||authornf, year, volnum, issnum;

SPOOL OUT
CLEAR  breaks
CLEAR  columns
CLEAR  computes
TTITLE  '' off
SET  pagesize 15
SET  newpage 1
SET  pause 'More' pause on
```

SQL*Plus report commands can be used to format simple reports, in this case a list of all articles by each author including the volume, number, and fee plus bonus paid.

**FIGURE 6:** ***Sample Output for Report 3***

```
Output of Report 3 (for Authors whose names start with C only)

PAYMENTS TO Chan, John

YEAR VOL NUM TITLE                                                    PD
---- --- --- -------------------------------------------------- -------
1985   3   1 Inner Workings of PL/1                                 1605
           5 Manipulating Asynchronous Communications                610
           6 How to Use Modems                                      1605
           7 Future Trends in CP/M                                  1210
             Legal Implications of Monitors                          810
**** *** ***                                                     -------
sum                                                                 5840


1986   4   1 Manipulating LAN Software                               615
             Product Review: PC-Mainframe Application               1010
             Integration
           3 Legal Implications of Mainframe Software Ported to     1410
             Micros
           4 Interfacing to PC Minicomputer Connections             1205
           5 Inner Workings of Printers                              815
           7 Legal Implications of Windowing Software               1210
             Interfacing to PC-Mainframe Application                 415
             Integration
          12 Interfacing to Tape Backup Systems                      205
             Future Trends in Multifunction Boards                   810
**** *** ***                                                     -------
sum                                                                 7695


1987   5   4 Legal Implications of COBOL                            1205
           7 Future Trends in Printers                              1015
           9 Manipulating Data Management                           1615
          11 Future Trends in Graphics Software                     1010
          12 Manipulating BASIC                                      615
**** *** ***                                                     -------
sum                                                                 5460
```

The sample output for the SQL*Plus report code (which is found in figure 5) is shown for one author. To produce a more complex report format, SQL*Report can be used.

format is done by manipulating data after it is loaded into the table. A log is generated showing the number of records loaded and amount rejected for not meeting edit criteria. Rejected records are placed in a separate file to be edited and the load tried again.

ODL does not support the common PC data exchange formats, delimited and DIF, nor any other program file structures such as dBASE's .DBF or Lotus 1-2-3's .WKS.

Export/Import utility programs permit data to be extracted from Professional ORACLE into a condensed ASCII form, which can then be moved between installations of ORACLE on different machines. The condensed ASCII form contains the information that is necessary to recreate the ORACLE representation of saved data, including table definitions, table data, grants, synonyms, view definitions, space definitions, and indexes. Data can be exported for entire databases, for single users, or for specified sets of tables.

The export and import programs process data only between ORACLE database format and ORACLE-specific storage and transmission format; not between different vendor products as is the usual definition of export and import in the PC environment.

To export data to other PC programs, a query must be developed that extracts desired data elements, formats them as a single string with needed delimiters and field truncation, and spools the output to a file. The maximum length of a fixed field output record is 999 characters.

## SAMPLE APPLICATION

The sample application used for all data manager reviews in the *PC Tech Journal* series was implemented for this review. The application specification consists of three data tables (Articles, Authors, Issues), a data-entry/update screen, queries, reports, and benchmarks. *PC Tech Journal*'s application tables are not generally normalized, although normalizing is the recommended approach for running relational data managers (see the sidebar, "Normalizing Databases," in "Relational Power, PC Ease," this issue, p. 95).

The SQL CREATE TABLE commands used to create the sample application are shown in figure 3. Because DATE cannot be imported directly into a field having the DATE data type, a two-step process was necessary. DATE fields were brought into a character field, **deadline**; then converted using the TO_DATE function and placed in the field **deaddate**, which has the DATE data type. The versatility of TO_DATE allows it to accept character date input in a number of different formats.

Once tables were created, data were loaded using the ODL utility. Because ORACLE does not directly import delimited field data files, the files were converted from delimited to fixed field format. This was done using dBASE III PLUS to import records into a single field of a table and parse the rows into

separate fields according to delimiters. The requirement that import data conform to a single format is a weakness of ORACLE in the PC environment, where program coexistence is supported through flexible data import/export features.

One other difficulty encountered was that a blank number column was read in as NULL rather than zero, thus precluding math processing until the NULL values were replaced with zeros. This was taken care of in a preprocess pass with dBASE, but it could also have been accomplished in ORACLE by using the SQL*Plus Null Value Function (NVL), which converts NULL values to a user-specified value and retains non-NULL values. Much processing could be avoided if ODL had access to existing ORACLE transformation functions, such as NVL and TO_DATE, during loading.

The Author table was loaded with ODL using the following control file specifications in the file AUTHOR.CTL:

```
define record impport as
  ln (char (18)), fn (char (12)),
    adr (char (20)),
  cty (char (16)), sta (char (2)),
    zip (char (5)),
  wph (char (10)), hpn (char (10)),
    ssn (char (9));
define source file
  from author.txt
  length 200
  containing impport;
for each record insert into author
(Lname,fname,addr,city,state,zip,
    work,home,ssn)
  values (ln,fn,adr,cty,sta,zip,wph,
    hpn,ssn)
next record
```

The following PC-DOS batch command file loads the author file and presents the log and reject files for review:

```
odl author.ctl logstuf.log user/password
type logstuf.log
pause
type logstuf.bad
```

The Articles and Issues tables were loaded in a similar manner.

**Queries.** All queries required by the sample application were developed directly in SQL*Plus (see figure 4). If such queries were used frequently by a data-entry person, they could be made part of an application developed using the SQL*Forms tool and driven by a menu block. SQL*Plus permits use of input parameters; when an SQL*Plus command encounters a parameter of the type &variable or &&variable, users are asked for a value. This feature permits queries to be made into parameters, as in the SQL*Plus example for the query, "How much did we pay per printed page for editorial in an issue? This should include articles that are not departments."

```
SELECT  sum(paymt + bonus)/
  sum(edpg + lstpg)
FROM article
WHERE category ! = 'department'
GROUP BY volnum, issnum
HAVING volnum = &volnum and
  issnum = &issue;
```

One bug was encountered in the area of referential integrity. A view was created as a query, then an SQL*Plus COLUMN command was issued to format a column of the view for an output report, which executed perfectly. The view was then dropped. When the user subsequently dropped the SQL*Plus COLUMN, the system entered a loop, endlessly repeating an error message.

**Reports.** Reports in the application were developed using simple SQL queries with SQL*Plus commands for format, breaks, and summations. Figure 5 shows the SQL*Plus program and figure 6, the output for one of the reports. The first few lines set up formatting, including the SPOOL command; then the SELECT command extracts data. The spool is then closed out and the formatting cleared. Neither SQL*Plus nor SQL*Report provides a simple way to specify conditional page breaks (for example, an author listing should not be started too close to the bottom of a page), but it is possible to program such breaks into reports produced using SQL*Report.

Address labels were written out using a short line length so the output lines would wrap onto the label. There is no provision to specify multiple labels across a page in SQL*Plus, but such output could be created with SQL*Reports. The DISTINCT clause eliminates duplicate label generation where an author of one article is also author or coauthor of another. The SQL UNION of two subqueries extracts both authors and coauthors from the Articles table; had the data been normalized the query would have been substantially simpler.

**Application screen.** SQL*Forms was used to create the article input screen specified as part of the *PC Tech Journal* sample application. Required data edit checks were implemented using SQL commands at appropriate field trigger points. The only difficult triggers in order to implement the checks were those to retrieve the senior author's phone number based on a data change in either the first- or last-name fields. Normalizing the database would reduce the complexity of triggers.

**Data entry and validation.** Data elements were validated through the form created with SQL*Forms. One validation that has been difficult, if not impossible, for many data managers reviewed in this series is the check of category and department fields. The category field must be one of four possible text values; the department field must be null if the category field is anything other than **department**, and must be one of four specified non-null values if the category is **department**. This was implemented in the SQL triggers by selecting a constant from a dummy table (called DUAL) to indicate success or failure of a trigger that includes a WHERE clause on a SELECT statement (see figure 7). Trigger success or failure in turn activates other triggers to accomplish conditional tasks.

The same technique can be used in triggers to verify that state abbreviations are valid and, in general, to provide validation for enumerated data types against lists of valid values.

**Benchmarks.** Except for the benchmark that loads the Authors table from an external file, all benchmarks were run under SQL*Plus. SQL made it easy to implement the benchmark that docu-

**FIGURE 7:** ***Example Trigger Definitions***

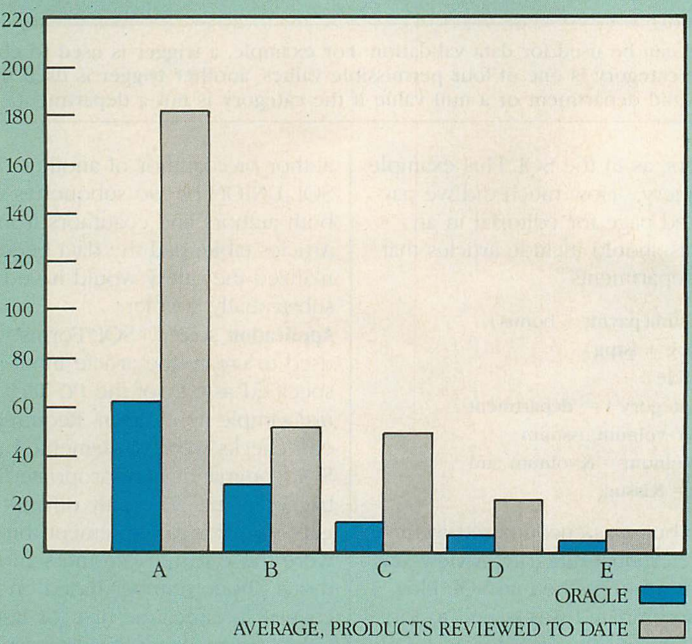
```
SELECT 'x'    /*trigger for Category*/
FROM dual
WHERE :category in ('Product Review','Technical Article','Department','Tech Notebook')

SELECT 'x'    /*trigger for Department*/
FROM dual
WHERE (:Category != 'Department' and Dept is Null)
   or (:Category = 'Department' and :Category is not Null
   and :dept in ('Programming Practices','Directions','Legal Brief','Product of the Month'))
```

Triggers can be used for data validation. For example, a trigger is used to check that the category is one of four permissible values; another trigger is used to accept a valid department or a null value if the category is not a department.

**FIGURE 8:** ***Benchmark Results***

| BENCHMARK TASK | TIME |
|---|---|
| A. Add 900 records to an empty database table | 62 |
| B. Index table on two fields (7 bytes) | 29 |
| C. Document and tally codes from one column | 13 |
| D. Mass change of one column (28 rows of 900) | 7 |
| E. Extract selected records to create a text file | 5 |




*All times are in seconds.*

*All benchmarks were run on an IBM PC/AT (6 MHz) with 640KB memory. The tests were run in an 8MB partition on a CMI 20MB disk under DOS 3.0.*

Professional ORACLE performs every benchmark better than average and offers the added benefits of a truly relational, mainframe-compatible data manager.

ments and tallies codes from one column, as shown below:

```
timing start 'STATE CODES WITHOUT
   PRIOR INDEX';
timing show

SELECT state, count(state)
FROM author
GROUP BY state
ORDER BY state;

timing stop
```

ORACLE displayed stellar performance on this benchmark and better-than-average performance on all others. One factor that contributes to ORACLE's speed is its infrequent disk accesses due to extensive buffering.

The benchmark requiring export of California authors to a delimited ASCII file is written as a query or report and spooled to a DOS file. Accordingly, the query included commands to trim, insert delimiters, and concatenate the output, as well as to select output data.

## POWERFUL PERFORMANCE

Professional ORACLE is the perfect relational data manger for developers who work in the ORACLE environment on larger computers and who want to implement data management operations and support in a PC and LAN environment. For developers who are attempting to create professional database systems "from the ground up" and are intending for them to grow into distributed or connected systems, Professional ORACLE offers the attractive promise of connectivity with IBM's DB2 and other relational database servers that support SQL.

Because Professional ORACLE is a relational data manager with SQL and 4GL programming tools, it requires an experienced professional to use it effectively for applications development. Developers with only procedural programming experience will have to undergo a reorientation before they can effectively use the nonprocedural interface in SQL*Forms for applications development. Once they have been reoriented, however, developers will experience a rather impressive reduction in development effort.

Normally, ORACLE would be excessive in its use of resources for many stand-alone applications, but savings in applications development effort could easily offset the cost of Professional ORACLE and its required PC resources in many other situations.

Oracle Corporation's decision to develop Professional ORACLE for the PC environment as but one more installation of standard ORACLE presents both benefits and drawbacks to PC developers. The primary benefit is Professional ORACLE's compatibility of applications across installation environments. The primary drawback is that Professional ORACLE does not take full advantage of rich user interfaces that are typical of the PC environment; the tools may be good by minicomputer and mainframe standards, but their user interfaces are not as smooth and congenial as those of programs that are specifically developed for PCs.

SQL*Forms, for example, provides pop-up windows of menus, but menu choices do not have associated hot keys, so the cursor must be moved to the desired selection. In addition, because of the 640KB memory limitation of DOS, the tools that are provided with Professional ORACLE are a subset of those provided in mainframe and minicomputer environments. It might take time to port the remainder to the PC and some might require waiting for operating system memory management beyond 640KB.

With the arrival of ORACLE, Relational Technology, Inc.'s INGRES, Software Systems Technology's XDB, Gupta Technology's SQLBase, INFORMIX Software's INFORMIX, and others in the PC LAN market, developers and users are beginning to see the rapid emergence of advanced professional relational data management technology in the PC marketplace. With Professional ORACLE, Oracle Corporation has made an excellent technical entrance.

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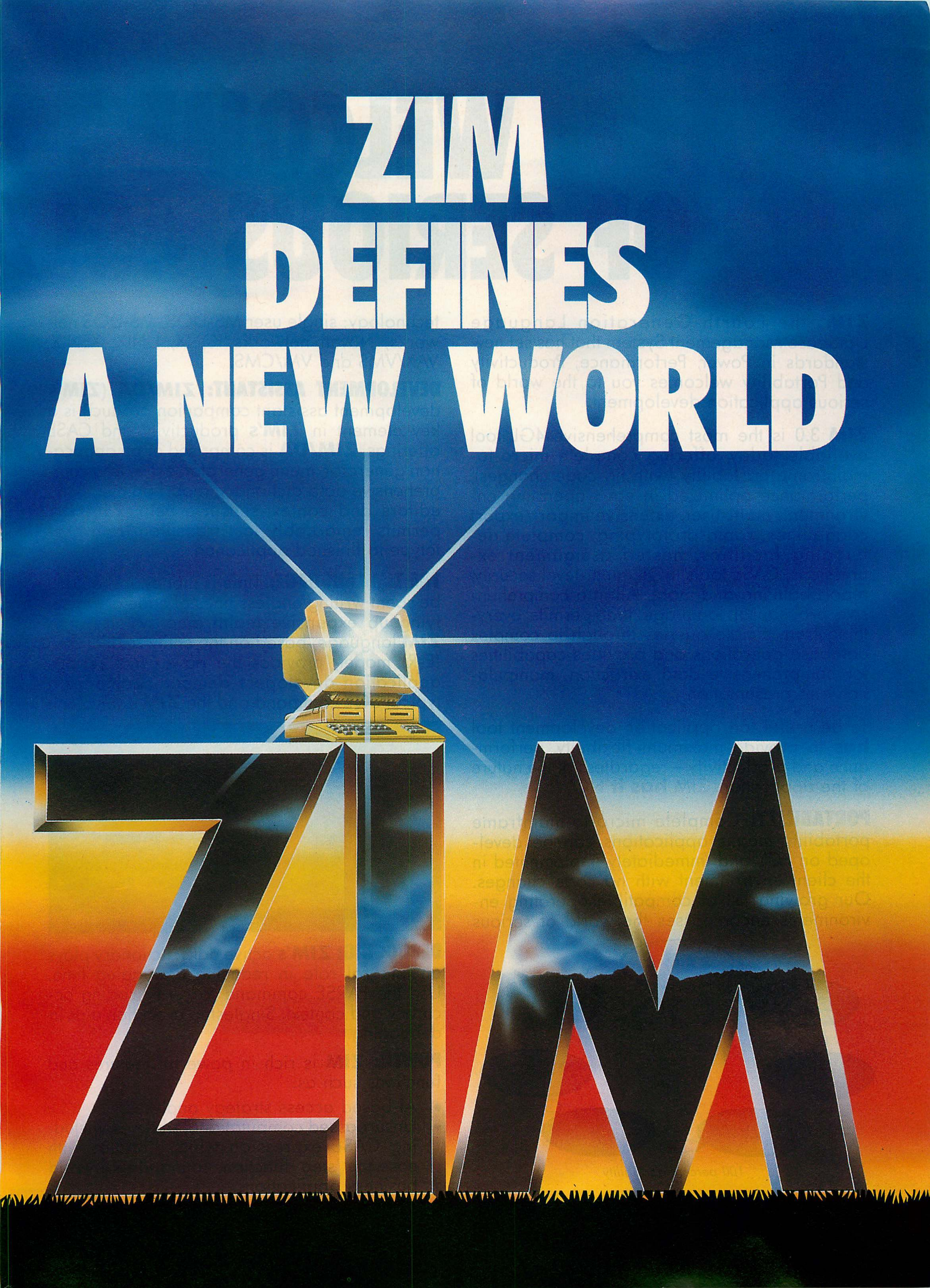
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ZIM

# WELCOME TO
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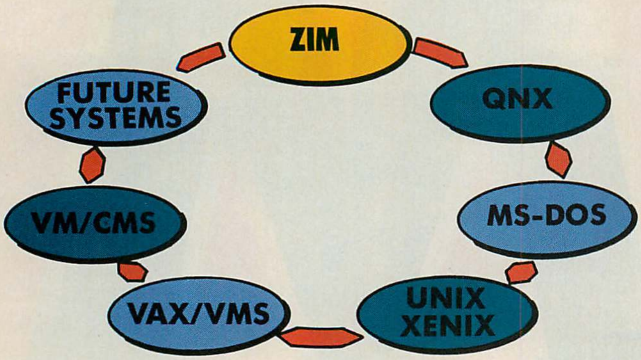
**ZIM,** the Fourth-Generation Language Database Management System that has set new standards in Power, Performance, Productivity and Portability welcomes you to the world of serious application development.

**ZIM** 3.0 is the most comprehensive 4GL tool available today, offering complete micro-to-mainframe portability (with no code changes), performance optimized in each operating environment, multi-user, extensive import/export capabilities, rapid prototyping, complete debugging facilities, nested assignment expressions, CASE tools, SQL, multi-level security, report painting and more. All in a comprehensive procedural language that permits everything from simple queries through to complex database operations and provides capabilities for comprehensive data extraction, manipulation and presentation.

To be useful, an application development tool **has** to provide maximum flexibility, performance and productivity—regardless of the nature of the application. ZIM **has it** NOW!

**PORTABILITY:** Complete micro-to-mainframe portability means applications can be developed on PC's and immediately implemented in the client environment with no code changes. Our growing list of compatible operating environments encompasses the world of serious technology: single user MS-DOS, MS-DOS networks, Novell networks, QNX, UNIX, XENIX, VAX/VMS and VM/CMS.




*100 percent portability*

**DEVELOPMENT ASSISTANT: ZIM/DA (ZIM's** development assistant companion product) is a key element in **ZIM's** productivity and CASE offerings. **ZIM/DA** is comprised of an application generator, menu generator, active and comprehensive data dictionary, report painter, code editors and context-sensitive help. **ZIM/DA** permits remarkably fast transition from prototype to finished application.

**THE ZIM LANGUAGE:** Time is money. It shouldn't be spent writing endless lines of code or worse, tying up expensive mainframe systems. The **ZIM** language, based on the entity-relationship (E-R) model, provides the power that serious application developers demand. Compare a typical SQL command and the **ZIM** equivalent:

**SQL:**
```
SELECT *
FROM WORKONTAB, PROJECTS, EMPLOYEES-
WHERE WORKONTAB.ENUM=EMPLOYEES.ENUM-
AND WORKONTAB.PNUM=PROJECTS.PNUM-
AND PROJNAME='ALPHA'
```
**ZIM:**
```
LIST ALL EMPLOYEES WORKON PROJECTS WHERE
PROJNAME='ALPHA'
```

**DEBUGGING: ZIM's** active data dictionary plays an integral role in reducing debugging time. Use the PARSE command to verify coding accuracy and context. Singlestep execution aids in debugging.

**POWER: ZIM** is rich in powerful features and functions such as:

- AI-based access strategy analyser.
- Unsurpassed computational abilities, including CASE expression which handles with ease the 'step' functions found in real-world business applications.

# THE WORLD DBMS PROGRAMMING

- Natural multi-user features including user-defined transactions, roll-back, audit trails and roll-forward.
- Complete code-data independence.
- Exceptional text-handling capabilities.
- Unlimited forms manipulation and report-writing capabilities.
- Multi-lingual applications (French, German etc.)

**SECURITY:** **ZIM's** multi-level security features include log-in, passwords, permission-based access to entity sets, relationships and fields and encryption/decryption of entity sets and relationships.

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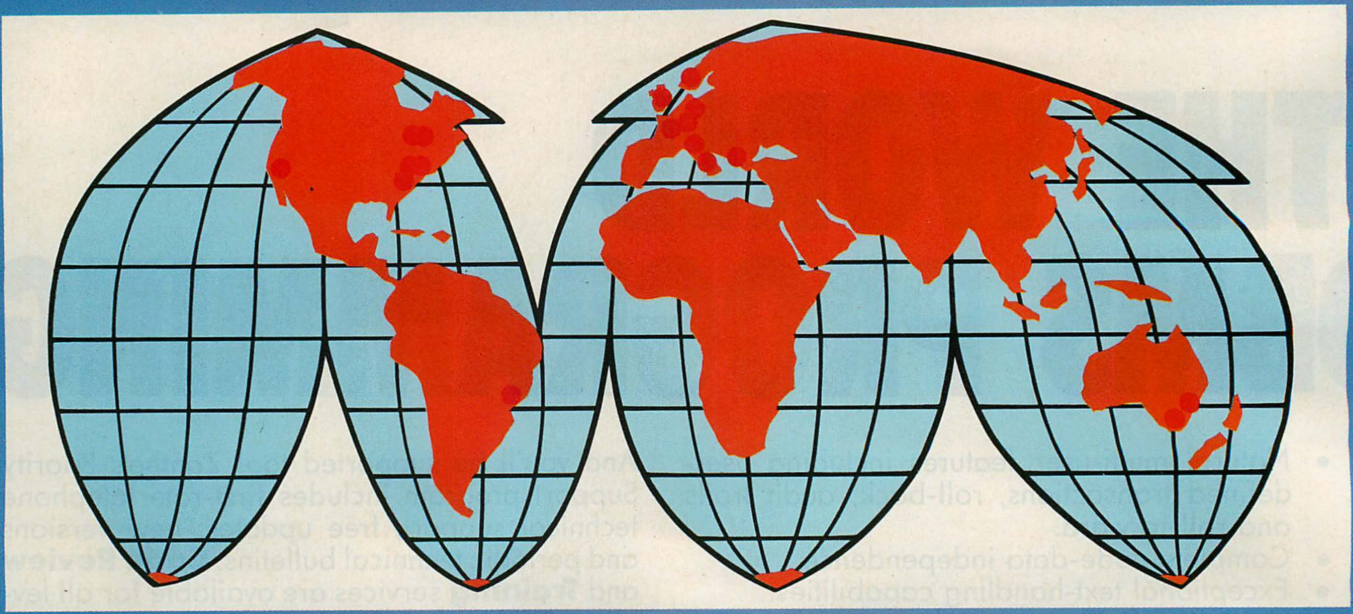

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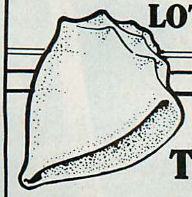

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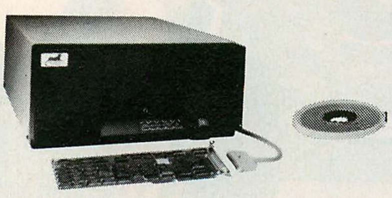

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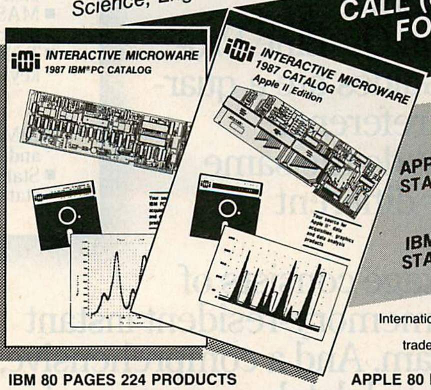


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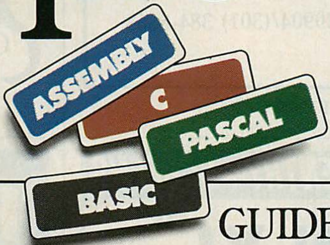


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- Tables: Line-drawing characters, ASCII chart, keyboard codes, error codes, operators, etc.

**C (600K each database)**
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- Preprocessor Directives: Describes commands, usage and syntax.
- Tables: ASCII chart, line-drawing characters, keyboard codes, error codes, operators, etc.

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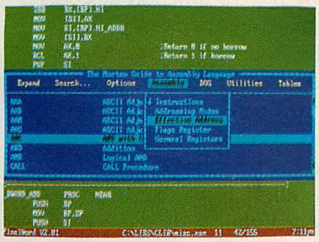

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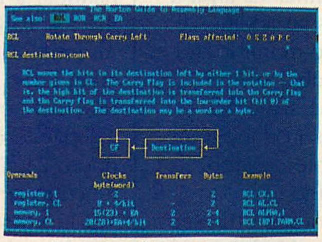

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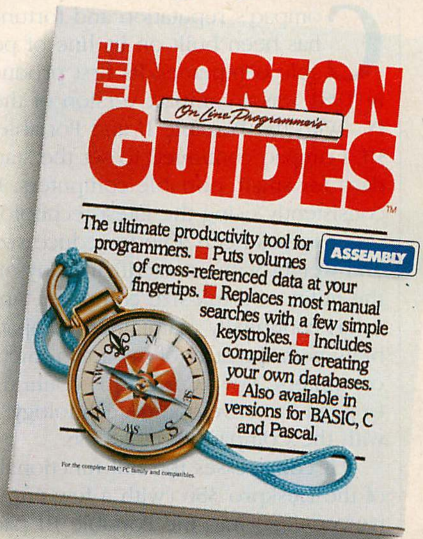


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## COMPAQ PORTABLE 386

# The Power of Convenience

*The Portable 386 compresses the full functionality of the Deskpro 386 into the Portable III package.*

DAVID CLAIBORNE

Compaq's reputation and fortune has been built on its line of portable computers. Its first product in 1981 was a compact version of the PC. With the Portable II and Portable III, Compaq continued to set the standard for small, portable computers. By consistently using the latest technology, Compaq has been able to reduce size and weight without sacrificing any of the utility of a full-size computer. And it has continually maintained compatibility with the state-of-the-art in microcomputers. Now, Compaq is continuing to push the envelope of technology with the Compaq Portable 386.

It compresses the full functionality of the Deskpro 386 (with a few enhancements) into the Portable III package. It is portable. It uses a 20-MHz Intel 80386 as its central processing unit (CPU), hence the "386" moniker.

The Portable 386 is priced competitively at $7,999. The Deskpro 386 (16 MHz) currently sells for $6,499, while the Deskpro 386/20 commands an asking price of $7,499 plus an additional $454 for a monochrome monitor and adapter. Therefore portable convenience can be had for the same price and in a machine that is just about as fast as the fastest available desktop.

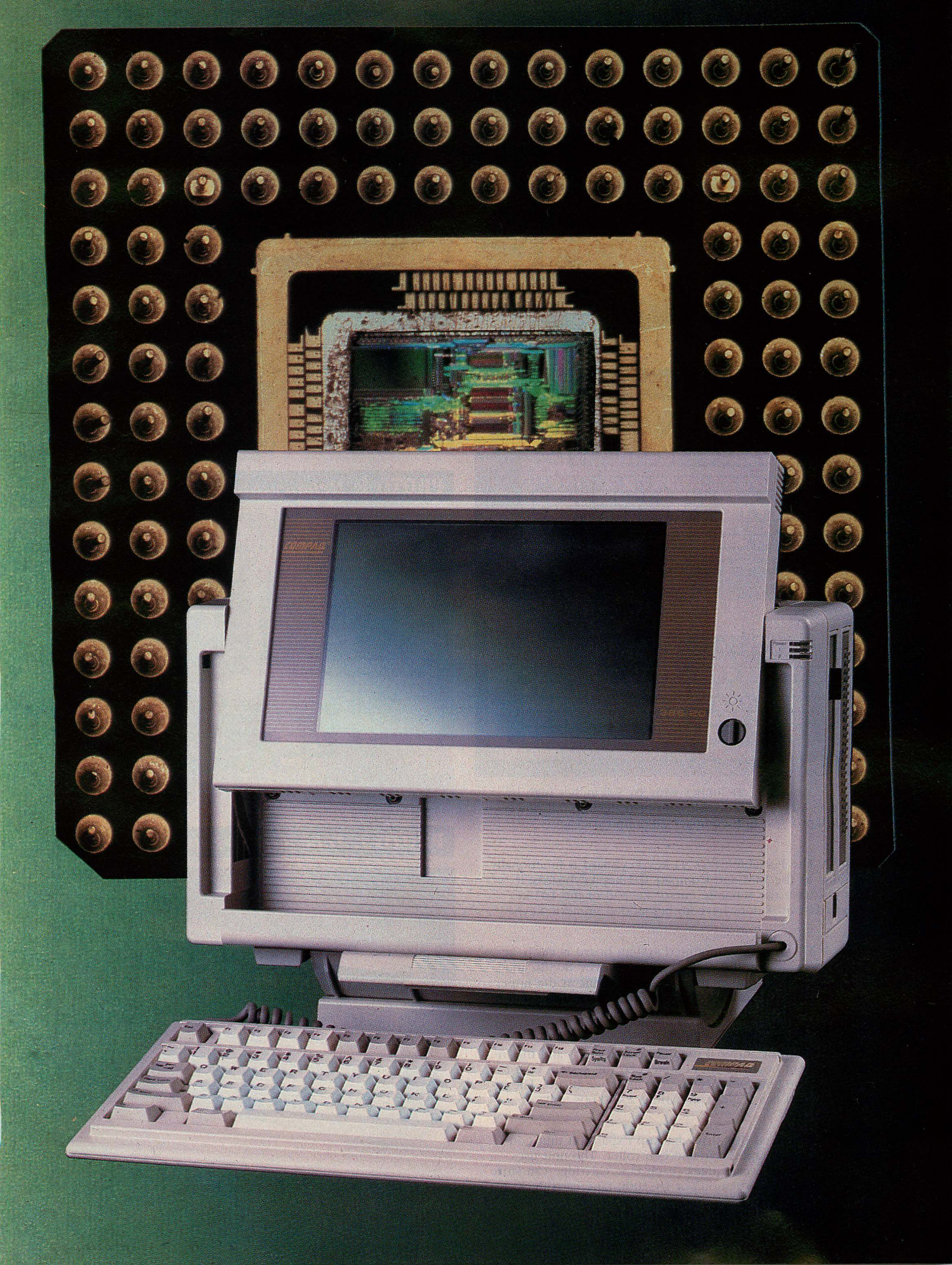
From the outside, the Compaq 386 looks exactly like the Portable III (see photo 1). Much of the technology used to develop the Portable III, such as the plasma display, the internal graphics card, and the expansion unit, has been incorporated into the new computer (see "Portable III," Jim Shields, May 1987, p. 76). Removing the keyboard of the Portable 386 to open up the unit reveals two minor changes.

First, the "386/20" logo is now displayed on the plasma screen, where "20" stands for the 20-MHz clock speed of the 80386 processor and the computer's internal bus, its 20-pound weight, and a Norton SI value of 23. Second, the keyboard has been expanded. It now has 12 function keys on the top row, matching pairs of Ctrl and Alt keys on the bottom row, and a separate PrtSc key. Unlike the Compaq and IBM 101-key keyboard, it does not have a separate cursor control pad (see photo 2). The horizontal spacing of the function keys differs from that of the 101-key keyboard; thus a different function-key template is required.

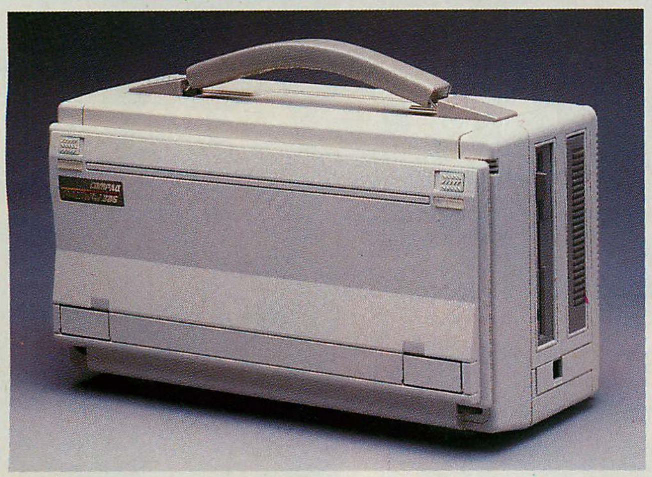
The Portable 386 comes standard with 1MB of 32-bit memory and a paged memory architecture to minimize the number of wait states during memory accesses. Consecutive accesses to the same 2KB page of memory occur with zero wait states, and accesses outside the current 2KB page occur with two wait states. Compaq estimates that, on average, the memory subsystem operates with less than one wait state per 32-bit memory access.

The Portable 386 comes equipped with two standard data storage devices. It uses third-height diskette and disk

PHOTOGRAPHY • MARC DAVID COHEN



## PHOTO 1: *Configured for Travel*



## PHOTO 2: *Keyboard Comparison*

*Photo 1:* Measuring 16-inches wide by 9.8-inches high by 7.8-inches deep, the Portable 386 provides the full power of a Deskpro 386 in a compact 20-pound package.

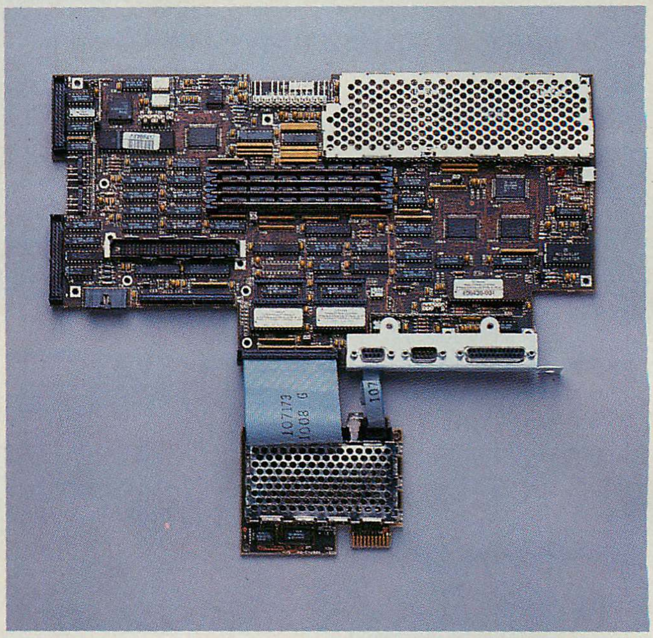
*Photo 2:* The Portable 386's 91-key keyboard is functionally the same as the IBM and Compaq 101-key keyboards; it does not have the separate cursor keypad of the 101-key keyboards, but it does have an embedded numeric keypad.

*Photo 3:* The vertically mounted system board is easily accessed by removing the case's rear panel. The 80386 and 80387 are located under the metal-mesh cage at the upper right; the video controller is mounted behind the system board parallel to the bottom of the case.

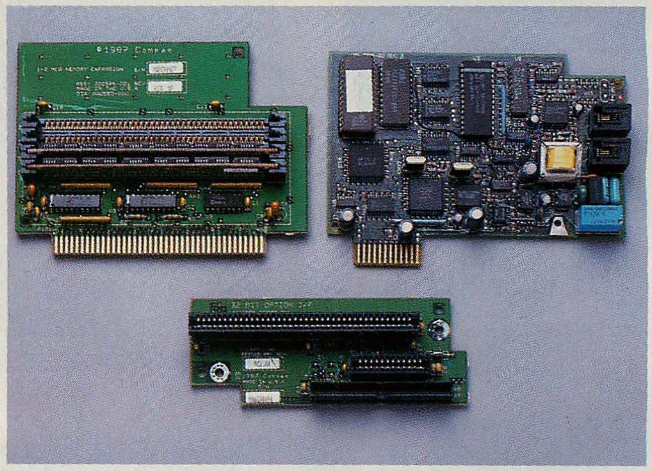
*Photo 4:* Both the internal memory board (left) and the internal modem board (right) connect to the system board through the 32-bit memory/modem interface board. The internal modem is a Hayes-compatible 2,400-bps unit.

*Photo 5:* The fixed disk-drive backup expansion unit contains a cartridge tape drive and controller. The unit uses 3MB DC2000 tape cartridges (each tape cartridge can store up to 40MB of information) or DC1000 tape cartridges.

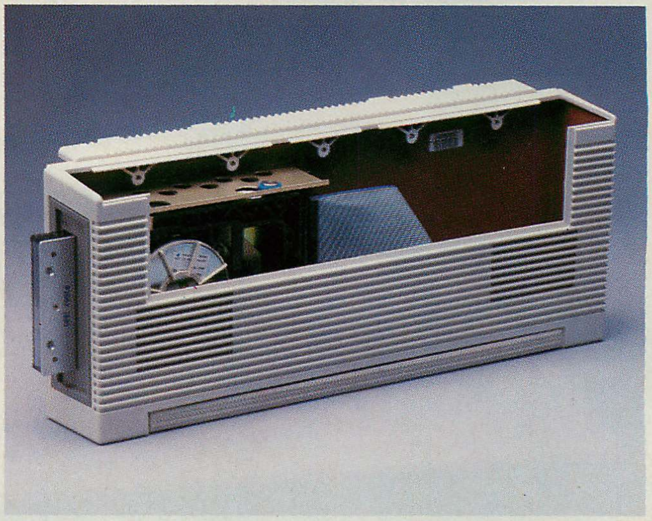
## PHOTO 3: *System and Video Boards*



## PHOTO 4: *Memory and Modem Boards*



## PHOTO 5: *Tape Backup Expansion Unit*



drives to achieve its compact size. A third-height, 5.25-inch, 1.2MB diskette drive provides removable media data storage. The second storage device is a quick (27-milliseconds access time) 40MB hard disk. (A 100MB drive is also available.) As has become standard with Compaq, the drives and their mountings are designed to withstand the day-to-day bouncing to which a portable computer is subjected.

Available options include a 360KB diskette drive, the expansion unit, internal memory expansion kits, an internal 1,200-bits-per-second (bps) modem, a desktop pedestal, the Compaq Enhanced Color Graphics Board (EGA compatible), and the Compaq Color Monitor. In addition, several new options are available with the Portable 386. The optional math coprocessor is a 20-MHz Intel 80387. A 2,400-bps internal modem can be used instead of the 1,200-bps unit. A board for providing a second internal serial port instead of an internal modem is available. A 40MB tape cartridge drive, packaged as an expansion unit, is available for hard-disk backups. A new internal memory board, using 1MB chips, is also available. Two such boards can be used in a piggyback fashion to add 8MB to system memory. The 2,400-bps internal modem and the 40MB tape cartridge drive also can be used with Compaq's Portable III machine.

The unit tested had 3MB memory, a 40MB drive, the 40MB tape cartridge drive, and the internal 2,400-bps modem. The test unit also included an expansion unit. In addition to the more conventional evaluation hardware, a Compaq Enhanced Color Graphic Board and Compaq Color Monitor were used. The entire system was housed in a luxurious, black leather (optional) carrying case.

### THE BARE BOARD

Removing the back cover (and thus exposing the system board) reveals the real differences in the Portable 386: surface-mounted application-specific integrated circuits (ASICs), a complete lack of switches, extensive use of radio-frequency interference (RFI) shielding, and the unique memory modules; see photo 3.

The Portable III used four ASICs, packaged in conventional IC packages, whereas the Portable 386 uses six ASICs plus one on video display card. The ASICs are all surface-mounted, which allows the chips to be soldered directly to the circuit board with no drilled holes. Automated manufacturing techniques make surface mounting feasible; however, only the most sophisticated repair shops can perform this task, which could make subsequent replacement of surface-mounted chips an expensive undertaking.

Compaq has designed the custom ASICs to allow them to reduce the total chip count and assembly cost of the new computer. The Portable 386 has only 62 chips on the system board (plus the memory modules). The ASICs are designed by Compaq and manufactured in Japan. Table 1 shows the basic functions of the six system-board ASICs.

The Portable 386 has no switches on the system board. Instead, all power-on settings are determined by jumpers, scattered at various points across the system board. The jumpers control system memory options (5 jumpers), serial (4) and parallel (3) interfaces, fixed disk options (2), and the keyboard controller clock speed (2). Individual jumpers set the fail-safe timer, the power-on system speed, the 80387 presence, power-on plasma display mode, and ROM size. One jumper currently is unused. Two more jumpers are only etched on the system board. The jumpers are preset at the factory for the system's initial configuration. They need to be changed only when performing operations that involve accessing the system board.

In a complex electronic package as small as the Portable 386, RFI may cause many insidious problems. In an effort to prevent such occurrences, Compaq has installed an extensive network of RFI shielding on the system board. Areas such as the video display interface, the disk-drive interfaces, and the external ports are separated from other components by vertical fences of metal mesh. The 80386, 80387 (when installed), and video controller board components are totally surrounded in a metal-mesh cage. In addition, a metal sheet shields the system board from other system components, and the entire inside of the computer casing is painted with an RFI-inhibiting coating.

Standard system-board memory is contained in two 512KB memory modules, 3/4-inch by 4-inch strips of printed circuit board containing six ICs. The modules plug into one of four sockets on the board. Each module is organized as 256KB by 18 (2 bytes, each with parity). Together, the pair of modules are organized as 256KB by 36 (4 bytes, each with parity) to provide a 32-bit memory system with 1MB of memory for the Portable 386. Two additional modules can be added to provide 2MB of memory on the board. Two of these modules may be added to the optional 1MB/2MB internal memory expansion board to raise the total system memory to 4MB.

Jumpers on the system board determine the amount of the standard 1MB of memory to be used as conventional memory. Choices are 256, 512, or 640KB, with a factory setting of

## COMPAQ PORTABLE 386 VITAL STATISTICS

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Serial interface
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40MB hard disk
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640KB. As is the case on the Deskpro 386, the remainder of the 1MB is addressed just beneath the 16MB address (FE0000H downward).

The 512KB modules are manufactured by Compaq. Because of their unique design, Compaq currently is the sole supplier of additional memory.

## A SIMPLE SETUP

Setting up the Portable 386 is easy and straightforward: fold down the keyboard, pop up the display, insert a bootable diskette in the diskette drive, and turn the machine on. The default settings of the internal jumpers do not need to be changed unless hardware is added to the system. Whenever jumpers are changed or new hardware is added, the SETUP utility program should be run to set the system configuration stored in CMOS memory.

The Portable 386 has no conventional internal slots. Its internal memory board and optional internal modem are installed in small minislots in the bottom of the system case. Adding hardware to the system is not difficult, so long as the new hardware is designed for the Portable 386 (that is, made by Compaq). The back of the system unit is easily removed with a Torx T-15 screw driver, exposing the complete system board.

To add the 80387 coprocessor, the top of the metal-mesh cage surrounding the processors must be carefully pried off to expose the 80387 socket. Then the new chip is inserted, the appropriate jumper setting (E20) is changed, and the mesh top is carefully replaced. When the system is turned back on, SETUP is run to place the new configuration into CMOS memory.

The first 1MB of additional memory is supplied by inserting two of the Compaq 512KB memory modules into the two vacant slots on the system board. Then the memory jumpers (E13 to E17) are changed to conform to the new memory size. Once again, SETUP must be run when the computer is turned on, in order to place the new configuration into CMOS memory.

Additional internal memory is provided by Compaq memory cards and the small internal slots. Two types of card are available: the 2MB card using the same memory modules as those used on the system board and the 4MB card with 1MB chips on a more conventional board. Two 4MB cards can be piggybacked to bring the total system memory to 10MB. The jumper settings must be changed and SETUP run to store the new configuration.

**TABLE 1:** ***ASIC Functions***

| |
|---|
| **PAGE MEMORY CONTROLLER** |
| Executes all requests from CPU for memory cycles at addresses used by 32-bit high-performance DRAM memory |
| Decodes addresses to see if internal (32-bit) or external (16-bit) |
| Sees if memory request in same page |
| **SMAP** |
| DMA memory page register |
| Refresh address counter |
| System ROM control |
| Speaker and NMI logic |
| Realtime clock/keyboard interface logic |
| Coprocessor interface logic |
| Timer clock generation |
| Keyboard processor clock generation |
| Address bit 20 and CPU restart control |
| **SYSTEM** (Two identical chips) |
| DMA controller |
| Interrupt controller |
| Interval timers |
| **EXPANSION BUS INTERFACE PERIPHERAL** |
| Driver control |
| Data transfer rate control |
| Serial port control |
| Parallel port control |
| Disk motors |
| Disk selection |
| Diskette drive controller |

**The Compaq Portable 386 uses six surface-mounted ASICs on the system board to reduce the total chip count and to lower the assembly cost.**

The optional internal modem also is installed easily by sliding it into the designated slot, changing the jumpers (E3, E4, E8, and E9), and then running the SETUP program.

The internal memory card and the internal modem card connect to the system board via a single interface card. This card has edge connectors for the memory and modem cards and a multipin connector for the system board (see photo 4).

Disk-drive installation should be undertaken only by a dealer. The system board must be removed to access the drives. Compaq builds a substantial portion of the drive controller into the drives, making third-party disk drives virtually impossible to use.

Replacing the lithium battery that maintains information in the system's CMOS memory also requires removal of the system board. The battery is mounted on the back of the metal plate that separates the board from the rest of the system. Fortunately, the battery is designed to last five years and should not require frequent changing. Compaq recommends that the battery be changed only by a dealer, noting that the battery "may explode if handled or connected improperly."

Adding hardware via the expansion unit can be somewhat more complicated. The expansion unit is a compact plastic case that attaches to the back of the system case. It has its own clock and communicates with the system board over an 8-MHz, 16-bit bus. The unit was used during the review to test Portable 386's compatibility with other boards. It accommodates two full-length IBM PC/AT-style boards, which may contain additional memory, communication interfaces, graphic display drivers, and so forth. Because the unit makes the machine bulkier, the computer sometimes is used without it. Depending on the boards in the expansion unit, the internal jumpers may need to be changed and/or SETUP rerun each time that the unit is added to or removed from the computer.

A new option with the Portable 386 is a clip-on, backup tape drive. The option packages an Irwin 40MB tape drive and the necessary drive electronics, including a custom Compaq ASIC, in the standard portable expansion unit (see photo 5). The entire unit is easily clipped on and off the Portable 386 (while the machine is turned off). It uses either the very small (3.25 inches by 2.5 inches by 5/8 inches) DC2000 tape cartridges (40MB) or DC1000 tape cartridges (10MB).

The tape drive endows the portable computer with the same capabilities available on earlier Compaq tape drives used with the Deskpro line. A new version of the tape utility, version 2.11 dated 9/4/87, is required to use the tape drive. Earlier versions of TAPE do not recognize the new drive. The TAPE program is provided with the tape drive itself, not with the standard Portable 386 user software.

Tape-drive performance reflects that of the Irwin drive. Because all communication with the tape drive is via the 8-MHz, 16-bit expansion bus, no speed enhancement is gained from the high-speed CPU. TAPE FORMAT requires almost 40 minutes to perform initial format of a tape cartridge. TAPE BACKUP copied 669 files containing 12MB in 11 minutes. TAPE DIR listed the 669 files in 5.5 minutes. TAPE RESTORE copied the files back to the hard disk in just under 8 minutes. The TAPE ERASE cleaned all files off the tape in 19 minutes. The computer screen displays a timer showing time

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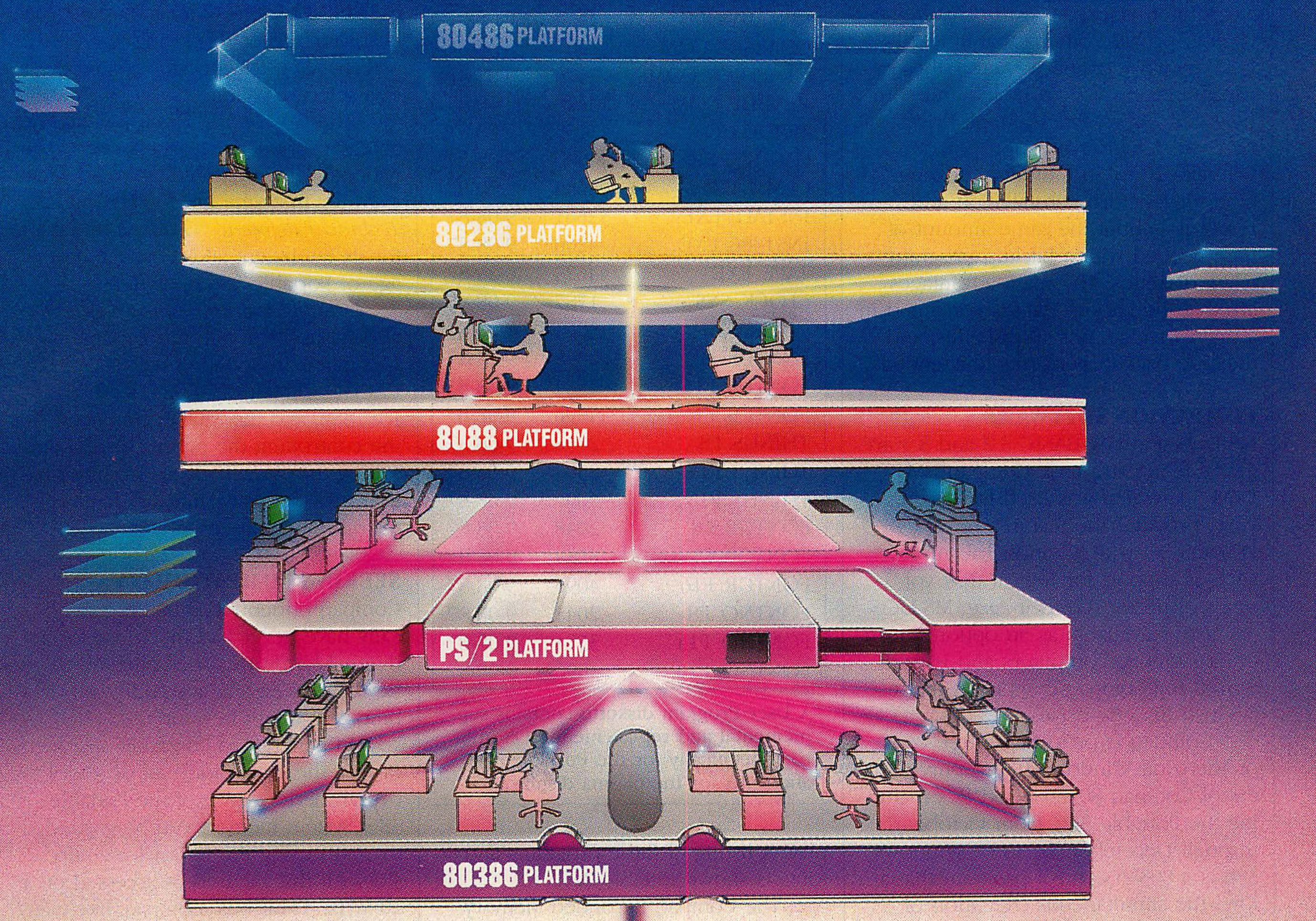


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remaining in the current operation when performing TAPE FORMAT, TAPE BACKUP, and TAPE ERASE.

The tape drive must be clipped onto the back of the machine to operate. If another expansion unit is being used to provide other capabilities (EGA card, network connector, etc.), these capabilities must be disabled and compensated for, so that the tape drive can be used. A typical backup operation will take 20 to 30 minutes, allowing time for tape-drive installation and removal—about the same amount of time needed with a backup program using diskettes. The main advantages are that the backup data is contained in a tiny cartridge, not 40 diskettes, and the tape backup performs unattended.

### COMPANION SOFTWARE

MS-DOS and GW-BASIC 3.2 and 3.3 are available at extra cost. Compaq's MS-DOS 3.3, which was used for this review, provides the features of IBM's PC-DOS 3.3 with additional features such as support for logical disk volumes of up to 512MB in size. MS-DOS 3.3 also is available as an option for all other Compaq computers and is required for Compaq computers that use 3.5-inch diskette drives.

Compaq is providing a free copy of Microsoft Windows/386 to purchasers of Compaq 80386-based PCs including the Portable 386, from October 1 through December 31, 1987. Windows/386 is a 80386 control program that allows the simultaneous execution of multiple MS-DOS and Microsoft Windows applications. The graphical user interface provide by Windows/386 is compatible with that of Microsoft Windows 2.0. Microsoft is offering a retail version of the product for a suggested retail price of $195.

A user diagnostics diskette is provided standard with the Portable 386. Also included is a very useful setup program. SETUP reads the system configuration from the jumper settings, compares the settings with both the actual hardware in the system and the configuration stored in CMOS memory, and determines what the system configuration should be. For most equipment configurations, SETUP will determine the proper configuration. Once the user accepts the configuration, it is automatically written to the CMOS memory for permanent storage.

Compaq supplies a User Program diskette that contains additional and replacement DOS utilities specifically for the Portable 386. The diskette also contains special fonts for the plasma display. A listing of these programs and fonts is shown in table 2.

**TABLE 2:** *User Programs*

| FILE NAME | BYTES | DATE |
|---|---|---|
| ADAPT. COM | 8272 | 9-08-87 |
| CEMM. COM | 1494 | 9-08-87 |
| CHARSET. COM | 2247 | 9-08-87 |
| GRAPHICS. COM | 7576 | 9-08-87 |
| KEYBDP. COM | 13228 | 9-08-87 |
| MODE. COM | 15159 | 9-08-87 |
| CACHE. EXE | 14000 | 9-08-87 |
| CEMM. EXE | 68032 | 9-08-87 |
| INSTALL. EXE | 32661 | 9-08-87 |
| INST386. EXE | 4260 | 9-08-87 |
| TAPE. EXE | 44624 | 6-25-87 |
| CLOCK. SYS | 1787 | 9-08-87 |
| VDISK. SYS | 3634 | 9-08-87 |
| FONTUS. F8 | 2048 | 9-08-87 |
| FONTUS. F14 | 3584 | 9-08-87 |
| FONTUS. F16 | 4096 | 9-08-87 |
| THINUS. F8 | 2048 | 9-08-87 |
| THINUS. F14 | 3584 | 9-08-87 |
| THINUS. F16 | 4096 | 9-08-87 |
| FONTGR. F8 | 2048 | 9-08-87 |
| FONTGR. F14 | 3584 | 9-08-87 |
| FONTGR. F16 | 4096 | 9-08-87 |
| FONTNO. F8 | 2048 | 9-08-87 |
| FONTNO. F14 | 3584 | 9-08-87 |
| FONTNO. F16 | 4096 | 9-08-87 |

**A User Program diskette contains supplemental and replacement DOS utilities specifically for the Portable 386, and fonts for the plasma display.**

The Compaq Expanded Memory Manager (CEMM) is this company's solution to providing consistent use of expanded memory. Using CEMM, all memory can be installed as extended memory. Then CEMM is used to divide extended memory into expanded and extended memory. The CACHE program uses a portion of conventional, extended, or expanded memory as a disk cache to speed up disk access. Since both programs divide the memory with software rather than hardware settings, memory can be reallocated without removing the system cover.

INSTALL and INST386 are menu-based programs that further simplify the reallocation process. The two programs create or modify the CONFIG.SYS file to install CACHE, CEMM, and VDISK on the system's fixed disk drive. The INST386 is designed specifically for the 386 computers and works in conjunction with INSTALL. Using the programs, system memory can quickly and easily be apportioned between a virtual disk (or disks), extended memory, expanded memory, and disk cache.

CHARSET works in conjunction with ADAPT to change the appearance of characters on the plasma display quickly and set the screen-save option from within an applications program. CHARSET specifies a main and alternate character set for displaying text on the screen. ADAPT switches between the two selected character sets.

The *Operations Guide* for the Portable 386 provides clear, concise explanations of the system that are adequate even for first-time users. The optional *Technical Reference Guide* is invaluable for its intelligent and thorough coverage of Portable 386 operations.

A *Supplemental Software Guide* also is supplied with the Portable 386. It contains information on ADAPT, CACHE, CEMM, CHARSET, INSTALL, INST386, and the MODE commands for the controlling the plasma display and setting the system speed. The information provided was sufficient for using the various utility programs.

### SEEKING COMPATIBILITY

Compaq portable computers intrinsically have never had much use for additional hardware. The company believes in providing any additional capability that might be required.

In general, adding additional memory via the expansion unit degrades the overall performance of the Portable 386. System memory can be expanded to 10MB using the internal memory slots. All this memory is accessed on a 20-MHz, 32-bit bus. Compaq, like many manufacturers of 386-based machines, has provided a definite reason to use only factory memory options.

The Portable 386 design is based on this premise. Most of the essential items are built in: a dual-mode plasma display, capable of displaying up to 640 pixels by 400 pixels; serial and parallel ports; and a port for driving a color display that is compatible with the IBM Color Graphics Adapter (CGA). Unless a high-resolution color display is absolutely required, no additional display board is needed. System-board memory can go to 2MB, with an additional 8MB on a Compaq card inside the case. The modem also is internal.

Still, there may be instances when another board must be installed, especially for external communications or other graphic displays. To provide for these contingencies, Compaq has provided the expansion unit.

Two external memory boards were tested, the Intel AboveBoard AT and the Cheetah Combo Board. Getting the cards into the expansion unit is not dif-

ficult, but the fit is tight. As stated in an earlier review of the Portable III, the expansion unit does not have a lot of space for fingers. Once the boards are in the unit, the unit is easy to clip on and off of the main computer.

Both cards performed without any problems once they were installed. Since the Portable 386 comes with at least 1MB of memory (the review unit had 3MB), all the memory on both cards was designated as extended memory. Then the Compaq utilities were used to divide the memory into extended memory, expanded memory, disk caches, and RAM disks. The system immediately recognized the extra memory during startup. Adding (or removing) additional memory in the expansion unit does not require changing the jumpers on the system board. However, SETUP must be run each time the memory is changed.

The next test involved placing the Hayes 1200B modem and the Compaq Enhanced Color Graphics board into the expansion unit. This necessitates shutting down the computer, installing the two new cards, removing the system unit cover to change jumpers to disable the internal modem and to set the plasma display power-on mode to monochrome display adapter (MDA), and finally putting the whole unit back together. When the system first comes up, SETUP must be run to update the system configuration.

The Hayes 1200B performed without any problems using Smartcom II. The external modem can be used as either COM1 or COM2 while keeping the internal serial port available as the other port. The Enhanced Color Graphics Board was configured as the secondary display controller and connected to a Compaq Color Monitor. The color monitor is selected using the MS-DOS MODE CO80 command; the plasma display is reselected using the MODE MONO command.

Both a bus and a serial version of the Microsoft mouse were tested; both versions worked well. The installation of the serial mouse takes about 30 seconds. Installation of the bus version takes longer, because it involves installing a board in one of the expansion unit's slots. The only problem is that either the system's internal serials port or one of the two expansion slots is used up. It would be nice if Compaq provided a separate, built-in mouse port. With the introduction of Windows 386 and the growing strength of graphic interfaces, a mouse is becoming a required computer peripheral.

The first test of software compatibility was the IBM AT Advanced Diagnostics (version 2.03). The Portable 386 passed, with three exceptions. The memory test recognized only 2,688KB of the 3,072KB present. This is because 384KB of the first 1,024KB is addressed just beneath the 16MB address, and thus discontiguous with the remainder of extended memory that is addressed from 1MB upward. The video display controller did not pass because the 640-by-400 pixel adapter is not an IBM standard controller. The math coprocessor test also failed because the IBM diagnostics are designed to test an 80287 math coprocessor, not the Portable 386's 80387 coprocessor.

Graphics software worked without problem. Microsoft Windows was installed using the AT&T 640-by-400 monochrome mode to provide an exceptionally sharp display. The Portable 386 was tested successfully with Microsoft Word, Version 4.0. Unlike earlier versions, this one takes full advantage of the plasma display's 640-by-400 graphics resolution.

Three memory-resident programs were tested, Borland's SideKick and Turbo Lightning and Living Videotext's Ready! All performed satisfactorily. Because of the different schemes that are used for showing highlighted text on the plasma display, some care must be taken in installing SideKick to ensure that the highlighted text is distinguishable. Turbo Lightning became extremely quick when the dictionaries were all loaded onto RAM disks.

Ready! also makes use of expanded memory. Again, the program performed flawlessly. The expanded memory is created using the CEMM utility. Smartcom II was used to test the communications capability of the Portable 386. Both the Hayes 1200B Smartmodem and the Compaq internal modem operated using Smartcom without displaying any problems.

Fastback from Fifth Generation was used to test the direct-memory-access capabilities of the computer. The Fastback setup program, FINSTALL, refused to allow 1.2MB diskettes to be used when the CPU was running at 20 MHZ (MODE SPEED = HIGH). Using MODE SPEED = AUTO (which causes the CPU to operate at a simulated 8 MHz when the diskette motor is on) eliminated the problem. Otherwise, Fastback performed beautifully.

**DOES IT MEASURE UP?**

The Portable 386's performance was tested using *PC Tech Journal*'s Evalua-

tion Suite. Test results are compared with the results of tests on an 8-MHz AT and the 16-MHz Compaq Deskpro 386. (For a full explanation of the tests, see "Out from the Shadow of IBM," Steven Armbrust, Ted Forgeron, and Paul Pierce, August 1986, p. 52, and "Updating the Evaluation Suite," Ted Forgeron, Paul Pierce, and Steven Armbrust, March 1987 p. 70.) Table 3 summarizes the results of the tests.

ATBIOS examines the BIOS and the BIOS date areas. The BIOS in the review unit had a Compaq copyright date of 7/2/87. ATKEY tests AT keyboard compatibility. The review unit passed the test, as well as the IBM AT Advanced Diagnostic keyboard test.

ATPERF measures memory access times and CPU and math coprocessor clock rates. The tests indicate that the Portable 386 performs RAM and ROM accesses over 3.5 times faster than the 8-MHz AT. The access times are also 15 to 20 percent faster than the Deskpro 386. These comparisons are all for accesses within the same 2KB page. (For a full explanation of this operation, see "The New Standard," by Steven Armbrust and Ted Forgeron, March 1987, p. 48.) Accesses outside the page are essentially twice as long because of the additional two wait states that are required. Because all data are accessed via a 32-bit bus, access times are the same for bytes, words (2 bytes), and double words (4 bytes).

Access times for ROM are the same as for RAM because, like the Deskpro 386, the Portable 386's BIOS is stored in 32-bit RAM when the system is operating. At system startup the Portable 386 copies the system BIOS and the Compaq Enhanced Graphics Board BIOS (if available) from ROM to the 128KB of 32-bit RAM beginning at FE0000H. This region is then mapped to the area normally reserved for system ROM (0E0000H to 0FFFFFH), thus allowing BIOS to be transparently accessed in high speed 32-bit RAM at either FE0000 or 0E0000H.

Video write performance using the Portable 386 internal video controller in CGA mode is almost exactly that of a CGA installed in an AT. More video write wait states are observed because of the 20-MHz CPU speed. The processor clock rate for both the 80386 and the 80387 is a full 20 MHz.

ATFLOAT measures the time taken to perform 100 multiplies on a 20-by-20 matrix and then compares the time to that required by an 8-MHz AT. The Portable 386 measures a blazing 7.8 times faster than the AT.

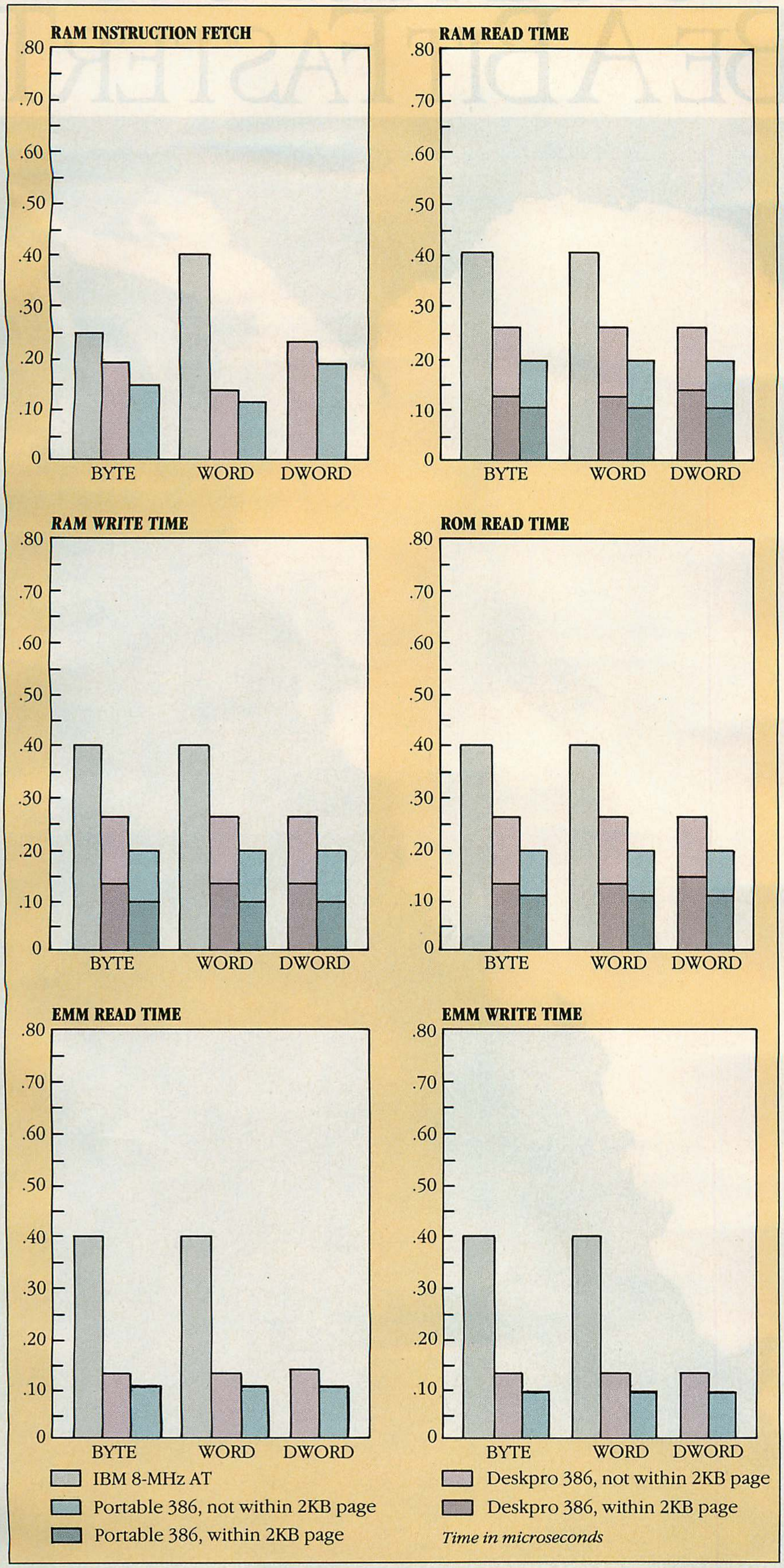
## TABLE 3: *Compatibility and Performance Tests*

| | 8-MHz AT 30MB DISK[a] | DESKPRO 386, 40MB DISK, 80387 | PORTABLE 386 40MB DISK |
|---|---|---|---|
| **ATBIOS** | | | |
| ROM BIOS date | 11/15/85 | 04/27/87 | 07/02/87 |
| **ATPERF** | | | |
| Average RAM instruction fetch ($\mu$s) | | | |
| BYTE | .25 | .19 (130)[b] | .15 (167) |
| WORD | .403 | .14 (280) | .12 (347) |
| DWORD | N/A | .23 | .19 |
| Average RAM read time ($\mu$s)[c] | | | |
| BYTE | .401 | .13/.26 (298/154) | .11/.20 (378/192) |
| WORD | .401 | .13/.26 (298/154) | .11/.20 (378/192) |
| DWORD | N/A | .14/.26 | .11/.20 |
| Average RAM write time ($\mu$s)[c] | | | |
| BYTE | .401 | .13/.26 (307/154) | .10/.20 (384/192) |
| WORD | .401 | .13/.26 (307/154) | .10/.20 (384/192) |
| DWORD | N/A | .13/.26 | .10/.20 |
| Average ROM read time ($\mu$s) | | | |
| BYTE | .401 | Same as RAM read | Same as RAM read |
| WORD | .401 | Same as RAM read | Same as RAM read |
| DWORD | N/A | Same as RAM read | Same as RAM read |
| Average CGA video write time ($\mu$s) | | | |
| BYTE | 1.208 | 1.21 (100) | 1.05 (115) |
| WORD | 2.415 | 2.42 (100) | 2.10 (115) |
| DWORD | N/A | 4.83 | 4.20 |
| Average EMM read time ($\mu$s)[d] | | | |
| BYTE | .402 | .13 (301) | .11 (378) |
| WORD | .402 | .13 (301) | .11 (378) |
| DWORD | N/A | .14 | .11 |
| Average EMM write time ($\mu$s)[d] | | | |
| BYTE | .402 | .13 (306) | .10 (384) |
| WORD | .402 | .13 (306) | .10 (384) |
| DWORD | N/A | .13 | .10 |
| CPU clock rate (MHz) | 8.0 | 16.0 (200) | 20.0 (250) |
| Math coprocessor clock rate (MHz) | 5.3 | 16.0 (300) | 20.0 (377) |
| Refresh overhead (%) | 7.1 | 15 | 16 |
| RAM read/write wait states | 1/1 | 0/0 | 0/0 |
| ROM read wait states | 1 | Same as RAM read | Same as RAM read |
| Video write wait states (CGA) | 8 | 17 | 19 |
| EMM read/write wait states | 1/1 | 0/0 | 0/0 |
| **ATFLOAT** | | | |
| Performance relative to AT (%) | 100 | 630 | 780 |
| **ATDISK** | | | |
| Sectors per track | 17 | 17 | 17 |
| Heads | 5 | 5 | 5 |
| Cylinders | 731 | 978 | 978 |
| Total space (million bytes) | 31.81 | 42.56 | 42.56 |
| Track-to-track seek time (ms) | 6.0 | 4.2 | 1.9 |
| Average seek time (ms) | 37.1 | 26.8 | 26.5 |
| Effective transfer rate (KB/sec) | 170.1 | 255.0 | 255.0 |
| DOS File I/O with/without cache (sec)[e] | 7.3 | 5.5/7.4 | 5.1/6.6 |
| Interleave | 3 | 2 | 2 |

*N/A = Not applicable*
[a] *The figures for the IBM PC/AT and Compaq Deskpro 386 are the average results from several machines, whereas the results from the Portable 386 are taken only from the review sample model.*
[b] *Figures in parentheses represent relative performance expressed as a percentage compared to PC Tech Journal's baseline machine, the 8-MHz, 30MB AT.*
[c] *For the Deskpro 386 and the Portable 386, first number is for memory access within the same 2KB page; second is for access not within the same page.*
[d] *EMM measurements were taken using the Deskpro 386 and Portable 386's built-in memory configured as expanded memory with the CEMM driver.*
[e] *The Compaq Deskpro 386 and Portable 386 were tested with and without Compaq's disk-caching program.*

**With an 80387 installed, the Portable 386 performs the 100 multiplies on a 20-by-20 matrix in ATFLOAT 7.8 times faster than an 8-MHz AT with an 80287 math coprocessor installed; the Deskpro 386 performs 6.3 times faster than the AT.**

## FIGURE 1: *Performance Comparison*




Portable 386 RAM and ROM access times within the same 2KB page are more than 350 and 15 percent faster than the PC/AT and Deskpro 386, respectively.

ATDISK evaluates hard-disk performance. The 40MB drive in the review system is very fast, clocking in with access times less than 30 milliseconds. The Compaq utility CACHE can be used to improve disk performance, as shown by the results in table 3. Using a 512KB cache in extended memory yields a 20 percent improvement in the DOS disk test and 3,000 percent improvement in the measured data transfer rate.

### SUPREMELY PORTABLE

The Portable 386 is a machine that can go easily from the office to the home and out of town, wherever AC power is available, with no compromise in computational power. Setup takes about two minutes, as long as it takes to pull the computer out of its case and plug it in. Just as quickly the computer can be back in its case, ready to go.

Because of the lack of conventional expansion slots, the Portable 386 sacrifices some of its utility. The expansion unit is functional, but not practical. If there is a pressing need for using the computer on a network or for using advanced graphic displays, the expansion unit does provide the means for installing the appropriate adapter boards. The addition of a mouse port and a Small Computer Systems Interface (SCSI) port to the standard ports would enhance the computer's utility.

The Portable 386, with its ASICs, memory modules, 20-MHz, 32-bit memory bus, nonstandard internal slots, and disk drives with built-in controllers, is definitely a computer that will be built and equipped largely by Compaq alone. For some time, all options will be available solely from Compaq. This causes no penalty in quality or utility, but Compaq charges full price for its quality and innovation.

Until the 80486 becomes available or Apple develops a Mac II portable, the Portable 386 is the most powerful portable personal computer available. With its surface-mounted ASICs, 20-MHz, 32-bit bus, efficient memory access scheme, and rapid-access disk drives, it is definitely the state-of-the-art portable personal computer.

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*David Claiborne is a technical manager for JAYCOR in Edgewood, MD. He has been working with PCs since 1982.*

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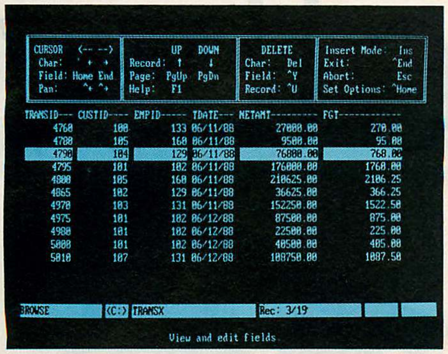
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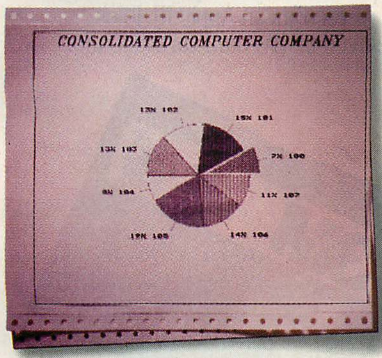

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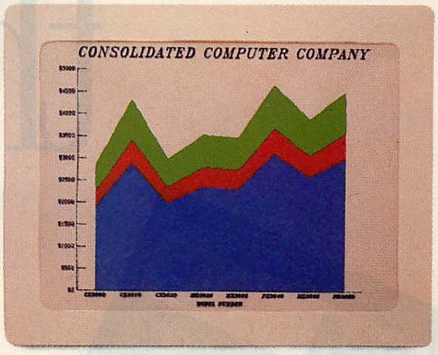

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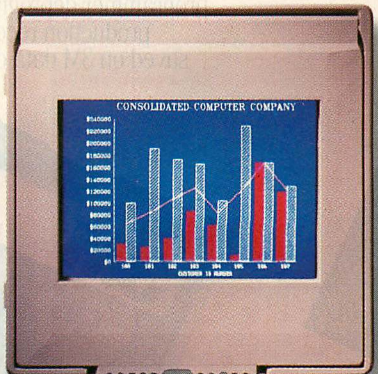

DB Graphics can produce a variety of output, including 35mm slides.

In fact, there's really only one kind of database presentation DB Graphics isn't capable of making. A dull one.

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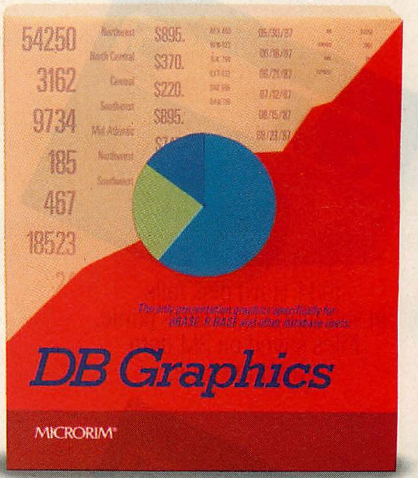
We could go on about the power, speed and accuracy of DB Graphics, but you really need to experience it for yourself.

So call our toll-free number (or from Alaska or Canada call 1-206-867-1800 Dept. PT1287) and order a DB Graphics Trial Pack for just $9.95 today. And start making the most out of your database.



The only presentation graphics software specifically designed for dBASE, R:BASE and other database software users.

DB Graphics also works with Lotus 1-2-3, Symphony, Multiplan and other data management files after translating to the ASCII, dBASE III/III PLUS or R:BASE format. DB Graphics is compatible with the IBM PS/2, PC, XT, AT and 100% compatible personal computers. It supports the IBM VGA, MCGA, EGA, CGA and Hercules display standards. It also supports most popular plotters, graphic printers, camera systems and laser printers from IBM, Epson, Hewlett-Packard and many others. © 1987 Microrim.

CIRCLE NO. 155 ON READER SERVICE CARD

# The more th
# the more they


1971. Kansas tornado blows out DEC™ PDP-IIs. Files saved on 3M data cartridge tape.*


1972. Moonlighting programmer deprograms company's production records. Files saved on 3M data cartridge tape.


1973. Fastidious janitor turns off IBM® 370. Files saved on 3M data cartridge tape.


1978. Colorado electric storm jolts Wangs.® Files saved on 3M data cartridge tape.


1979. Little Stevie Fong flips floppies out father's office window. Files saved on 3M data cartridge tape.


1980. Temporary help permanently dumps accounting records on Apple III. Files saved on 3M data cartridge tape.


1984. Hard disk fails in soft market; brokers panic. Files saved on 3M data cartridge tape.


1985. Sal's Diner. Dropped eggs scramble Macs.™ Files saved on 3M data cartridge tape.


1987. Delivery boy delivers IBM PS/2™ swiftly and abruptly to the sidewalk. Files saved on 3M data cartridge tape.



# ings change,
# stay the same.

1975. Head of the office trips, pulls plug on *HP*® 3000. Files saved on 3M data cartridge tape.

1976. Unnamed computer does the unmentionable. Files saved on 3M data cartridge tape.

1977. Office fire bakes Apple® IIs. Files saved on 3M data cartridge tape.

1981. Circuit breaker flips, floppies flop. Files saved on 3M data cartridge tape.

1982. Head crash proves fatal to Lisa.™ Files saved on 3M data cartridge tape.

1983. Thief sneaks away with Osbornes.® Files saved on 3M data cartridge tape.

1990. Somewhere, somehow, on some computer, data will crash. Files will be saved on 3M data cartridge tape.

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But when they go out abruptly, you've always been able to rely on 3M data cartridge tape for backup.

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*True to life stories.

CIRCLE NO. 164 ON READER SERVICE CARD

## PC's LIMITED $386^{16}$

# Price/Performance Leader

*Although it has a bargain-basement image to overcome, PC's Limited has produced a quality, high-end 386 machine, but still at highly attractive discount prices.*

SUSAN HOLLY and JIM SHIELDS

The speed may grab your attention first. Or it may be the price. Taken together, blazing speed and rock-bottom price add up to a machine that is generally accepted as boasting the best price/performance ratio in the 386 market. The PC's Limited $386^{16}$ sells for $3,000 less than the market leader, Compaq's 16-MHz Deskpro 386, and is capable of faster performance.

To succeed in this high-end market, however, the $386^{16}$ has to overcome the PC's Limited persona of a cut-rate, mail-order house. Indeed, the company is taking steps to project a more professional image and to attract the ever-important corporate customer. "We want the major corporations to feel comfortable doing business with us," said John Ellett, manager of marketing communications. "We want to do that any way we can, without abandoning our loyal customers."

So these days the company is wearing a more formal corporate name (Dell Computer Corporation, named after the 22-year-old chairman and founder Michael Dell), it has given its computers a chic new chassis, and it is keeping pace with the industry by introducing sophisticated, high-performance machines.

The company's goal is "not an image change so much as an attempt to eliminate confusion," Ellett said. "The mail-order label was hung on us and is inaccurate." He explained that Dell is a manufacturing company that sells its own PC's Limited brand of computers directly to its customers. The $386^{16}$ is the newest member of the family, which includes the 8088-based Turbo and the $286^{8}$ and $286^{12}$. First deliveries of the $386^{16}$ were in June.

The base model $386^{16}$ houses 1MB of memory, one parallel and two serial interfaces, a realtime clock, a 101-key IBM-like keyboard, a 1.2MB diskette drive, and a 40MB hard disk. With monochrome monitor and Hercules-compatible monochrome adapter, it sells for $4,299; an EGA-compatible system and color monitor add $500 to the base price. Also available are 70MB and 150MB hard-disk models. By way of comparison, the 16-MHz Deskpro 386 with 40MB hard disk is listed at $6,499—*without* monitor and display adapter, which adds another $1,000 to the price. A similarly configured IBM PS/2 Model 80 is roughly $8,500.

**UNIQUE SPEED**

Of course, all 386 machines are fast, but there are varying degrees of "fast." The way in which the PC's Limited $386^{16}$ achieves its speed is what sets it apart from its competitors and ranks it among the fastest of the fast. It uses 32-bit, zero-wait-state static RAM (SRAM) to take full advantage of the 16-MHz 386 processor. Conventional dynamic RAM (DRAM) used with most 386 systems cannot keep pace with the processor and thus requires insertion of

PHOTOGRAPHY • MARC DAVID COHEN


MITSUBISHI
PC'S LIMITED 386

**PHOTO 1:** *SmartVu Display*

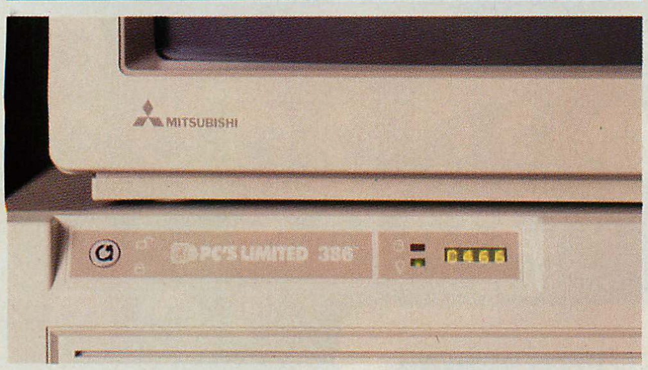



**PHOTO 2:** *Keyboard Comparison*

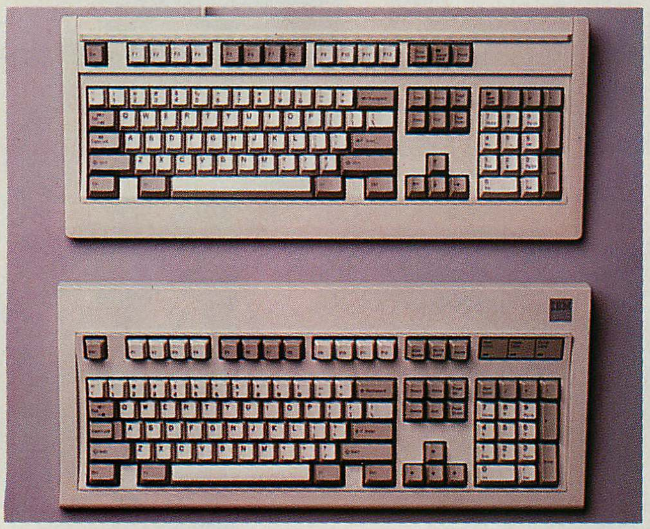


**PHOTO 3:** *Rear of the System Unit*

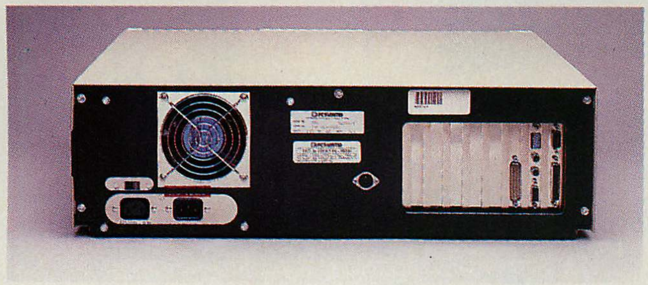


**PHOTO 4:** *Inside the System Unit*

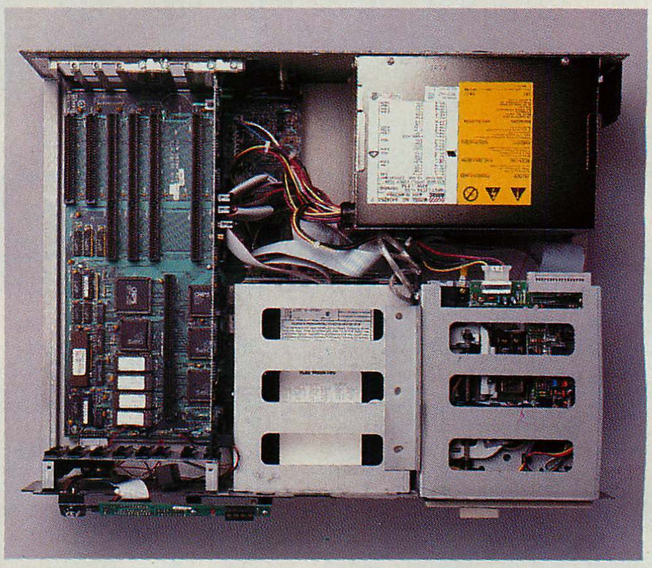


**PHOTO 5:** *$386^{16}$ System Board*

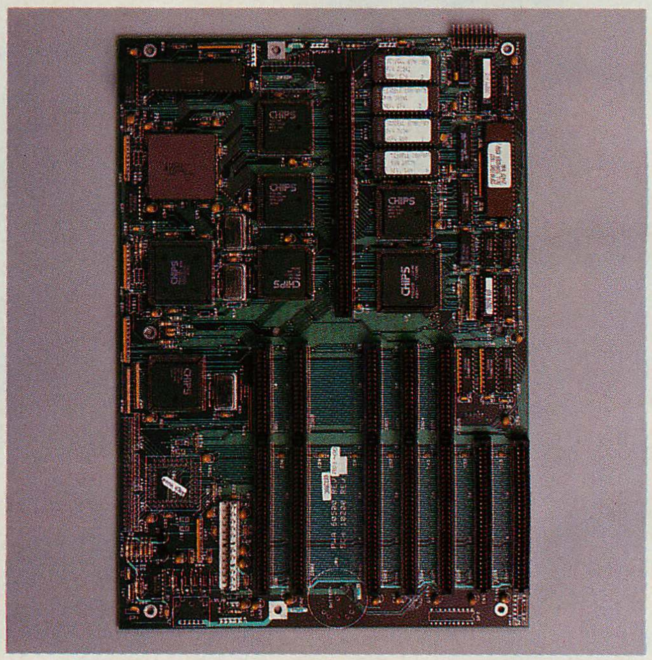


**PHOTO 6:** *System Memory Board*

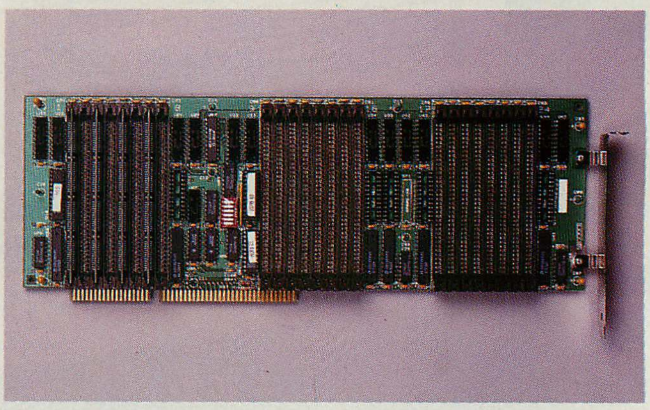


*Photo 1:* The SmartVu LED display on the beveled front edge shows error messages and the letter and cylinder number of the disk drive currently being accessed.

*Photo 2:* The PC's Limited keyboard differs from IBM in that the CapsLock, NumLock, and ScrollLock indicators are embedded in the keys rather than in a separate panel.

*Photo 3:* The rear of the system unit features an AT-style layout. Note the secondary serial port's 25-pin female D-shell connector to the left of the serial/parallel adapter.

*Photo 4:* The system unit has a similar layout to that of an AT. One unfortunate exception, however, is that both the 80386 and 80287 are located under the left disk bay.

*Photo 5:* The system board contains no RAM. The forward socket in slot 6 is for the 32-bit system memory board.

*Photo 6:* One to six megabytes of 32-bit zero-wait-state SRAM may inhabit the system memory board.

wait states so memory can catch up. This substantially reduces performance, negating much of the speed advantage of the 386 processor.

Because SRAM is quite expensive, other manufacturers of 386-based machines have tried alternative methods to overcome the problem. Compaq, for example, has taken a compromise position between cost and speed. Its Deskpro 386 uses a memory-paging scheme implemented through static-column RAM chips in which each 1MB bank of RAM is divided into rows and columns for easier access to memory. Memory is divided into 2KB pages; memory accesses within the same 2KB page require no wait states, but if the memory to be accessed is located in a different page, as is often the case, the system incurs two wait states (for a more complete explanation see "Compatibility and Performance: The New Standard," Steven Armbrust and Ted Forgeron, March 1987, p. 48).

Advanced Logic Research (ALR) took a far less costly approach. The ALR Access 386 uses a memory-interleaving scheme in which the system's DRAM chips are divided into two banks. Ideally, memory accesses alternate between banks, so one memory bank can recover while the other is being accessed; in practice, however, applications are not that cooperative and wait states are often inserted (see "Compatibility and Performance: Poised for Tomorrow," Michael Abrash and Dan Illowsky, April 1987, p. 104).

PC's Limited, on the other hand, took the more expedient—albeit most expensive—route of "true" 32-bit SRAM, which requires no wait states. Whereas the Compaq and ALR methods are fast only some of the time (depending on the application), the $386^{16}$'s SRAM is effective all the time.

All of the $386^{16}$'s SRAM resides on the static memory board, which fits in a special 32-bit slot on the system board. The system board itself contains no memory, as is the case with the Deskpro 386's system board.

The proprietary static memory board comes with 1MB of SRAM and can be expanded (in 1MB increments) to 6MB. This compares to the Deskpro 386, which also supplies a 32-bit memory board that fits in a special slot on its system board, and with piggyback cards can hold up to 10MB of RAM. The PC's Limited memory board has numbered sockets for 24 SRAM modules to accommodate all system memory. Each module has eight SRAM chips—four mounted on each side; each 1MB increment consists of four modules. PC's Limited offers the 1MB memory expansion option for $500.

For compatibility with software designed to run on earlier generations of computers, the PC's Limited $386^{16}$ has changeable processor speeds. The machine powers up at 16 MHz, but pressing the Ctrl-Alt-\ key combination causes it to operate at a lower speed—emulating either a 4.77-MHz PC or an 8-MHz AT. Whereas the $386^{16}$ can make this switch only manually from the keyboard, the Deskpro 386 uses the more automatic software method. Deskpro users can insert a MODE command in a batch file at the beginning and end of a program that requires 8-MHz mode, for example. PC's Limited emulates slower processor speeds by inserting extra wait states; Compaq does so by extending the memory refresh cycle.

The PC's Limited machine signals a change in speed with sound: a single tone for the slower speed, a two-pitch tone for returning to 16 MHz. The $386^{16}$ offers the choice of only two speeds at a time, one of which is always 16 MHz. The user must decide during set-up whether the optional slower speed will be 4.77 or 8 MHz.

**DUAL-SPEED BUS**

The PC's Limited speed advantage comes not only from running the 16-MHz 386 processor at maximum efficiency, but also from an unusual two-speed expansion bus that can bring out the best in some expansion cards. Whereas the expansion buses of the Compaq and ALR machines operate at 8 MHz to accommodate boards designed for the 8-MHz AT, the PC's Limited bus works at 12 MHz as well as at 8 MHz. The dual-speed bus is therefore as much (or more) a performance feature as a compatibility feature.

The system arrives with the bus speed set at 8 MHz. The user can change that default speed to 12 MHz through the Advanced Options menu of the set-up program. The bus speed must always be set to the speed of the slowest board installed in the system, because boards designed for 8 MHz may not operate properly at 12 MHz.

## PC'S LIMITED $386^{16}$ VITAL STATISTICS

**Base Model** $4,299
($4,799 with an EGA-compatible adapter and display)
16-MHz Intel 80386 microprocessor
1MB memory
Realtime clock
80287 socket
Monochrome graphics adapter and display
Parallel printer interface
Two serial interfaces
1.2MB or 360KB diskette drive
40MB hard disk

**70MB Model** $4,699
($5,199 with an EGA-compatible adapter and display)
Includes all features of the base model except it has a 70MB hard disk instead of a 40MB hard disk.

**150MB Model** $5,999
($6,499 with an EGA-compatible adapter and display)
Includes all features of 70MB model except it has a 150MB hard disk instead of a 70MB hard disk.

**Memory capacity on system board**
None.

**32-bit memory capacity of system**
6MB

**Display adapters**
Either a Hercules-compatible monochrome graphics adapter or an EGA-compatible color video adapter can be installed.

**Monitors**
Either an IBM-compatible monochrome or an enhanced color display can be used.

**Expansion slots**
32-bit: 1
16-bit: 5
8-bit: 2

**Available slots**
40MB or 70MB Model
32-bit: 0
16-bit: 3[a]
8-bit: 0
150MB Model
32-bit: 0
16-bit: 2[a]
8-bit: 0

**Other extras available**

| | |
|---|---|
| 1MB memory option | $499 |
| 80287-8 math coprocessor | $379 |
| 360KB diskette drive | $109 |

*[a]One additional 16-bit slot is available if the mounting bracket for the second serial port is not used.*

Thus, this feature is useful only if you have an all-12-MHz chorus singing in your system. Although not many expansion boards currently on the market are guaranteed to operate at 12 MHz, PC's Limited says its own cards do.

**CHIC STYLING**

While the speed of the $386^{16}$ dominates any discussion about it, other factors must be considered. Perhaps not as exciting as the machinations going on inside, but important in their own right, are the outward appearance and user interface. In styling its newest machine, PC's Limited has become more fashion conscious; the $386^{16}$ has a distinguished look. Its front vents lie horizontally rather than in the typical vertical orientation of the AT; and a most distinctive styling detail is the beveled edge of the front of the system unit cover to showcase PC's Limited's popular SmartVu display (photo 1).

Introduced on the PC's Limited 286 computers, SmartVu has been a hit with users because of its entertainment value, if nothing else. The four-character diagnostic display is the user's view port into the inside of the system unit, responding to user commands and reporting on internal operations. As the computer goes through its diagnostic tests at boot-up, the panel flashes through (at speeds almost too fast to read) the names of power-on routines, such as RAM4, RAM5, optR, Math, and Boot. This sequence ends with a display of the drive letter and cylinder number of the disk in use (if boot-up is attempted with a diskette in drive A:, the message is A:00). The drive ID and cylinder number appear whenever a disk is accessed, which could be helpful for debugging. When the $386^{16}$ changes processor speeds, SmartVu displays the new active speed.

Perhaps SmartVu's most important job is displaying error messages. Three types of error codes may appear: the letters *ER* followed by two digits refer to the nine system errors listed in the PC's Limited manual, such as "80386 CPU computation failure" or "8254 timer is inaccurate or not clocking"; an error message prefaced with an *S* signifies failure of an SRAM chip and provides the socket and number of the defective chip; a message prefaced with *Db* indicates a memory expansion error and shows the failing bit position.

Although the beveled edge of the SmartVu panel is an attractive touch, its angle can pick up glare from overhead lights, making for difficult reading of the LED display. Located on the panel with SmartVu are the green-light power indicator and the red-light disk access lamp, along with the keylock.

The $386^{16}$ chassis has the solid feel of an IBM product, and in most respects, PC's Limited follows IBM's lead in arranging its components. The size—21.1-by-16.5-by-6.5 inches—is nearly identical to the AT, whereas the PC's Limited $286^{12}$ had a 25-percent smaller footprint, paying the penalty in disk-drive space. Like the AT the $386^{16}$ has one full-height and three half-height disk-drive bays, two of which are accessible from the front with the cover on. The reviewed unit contained a 40MB half-height hard disk in the lower portion of the full-height bay and a half-height 1.2MB diskette drive in the upper of the three half-height bays. A 360KB half-height diskette drive is available from PC's Limited in addition to or in place of the 1.2MB unit.

Key for key, the $386^{16}$'s keyboard mimics IBM's 101-key arrangement, although neither PC's Limited nor any other compatible manufacturer has yet matched the feel of an IBM keyboard (photo 2). PC's Limited tends toward the "squishy," registering a letter on the screen before the key is pressed more than halfway down. This often results in stray letters appearing in the middle of words during fast typing exercises. The keys provide little tactile or audio feedback, and unlike Compaq, PC's Limited has no option for the user to set audible key clicking. Indicator lights for the CapsLock, NumLock, and ScrollLock keys are embedded in the actual keys rather than in a separate panel as on the IBM keyboard.

Two other differences from the IBM keyboard pose minor inconveniences. First, the cable on the IBM model is detachable from both ends, but on the $386^{16}$ it cannot be detached from the keyboard end, so the user must reach around to the rear of the machine to remove the keyboard. Second, although the overall dimensions of the two keyboards are the same, PC's Limited's leaves more room at the bottom (presumably as a wrist rest) and less at the top, so templates designed for the AT's function keys do not fit on the PC's Limited keyboard.

The $386^{16}$ is sold with either an IBM-compatible monochrome or enhanced color monitor. The review model arrived with a Mitsubishi Model XC 1430C enhanced color monitor that appears to be identical to the Compaq Color Monitor sold with the Deskpro models. Also included with the review model was an EGA-compatible VEGA



board, manufactured by Video Seven. The VEGA comes with 256KB of video memory and, when used with a monochrome monitor and the accompanying software, can provide 720-by-348 pixel Hercules-compatible graphics and can normal EGA functions.

The $386^{16}$ has one parallel and two serial ports. Making two serial ports—one with a 9-pin Canon D-shell connector and one with a 25-pin connector—a standard feature was a wise move by PC's Limited not only to provide users with an extra port, but also to cover users who are upgrading from either the AT, which uses a 9-pin serial port, or the PC, which uses a 25-pin port. Although not an advertised feature, a game port was included in the reviewed machine—but without the cable and mounting bracket to connect from the port to the rear of the case.

The rear of the $386^{16}$ is much like the AT's, with three-prong power cord connector and 115/230 voltage switch on the left, keyboard connector in the center, and expansion slots and video connector on the right (photo 3).

**THE INSIDE STORY**

Penetrating the system unit is merely a matter of removing five one-quarter-inch slotted hexagonal screws from the rear of the case and sliding it off. Real estate inside the unit is laid out much like the AT, with the system board on the left, the disk-drive bays on the right, and the power supply located behind them (photo 4).

The system board itself, measuring 9-by-13 inches, is about the size of that of an AT or Deskpro 386 (photo 5). Its proprietary design uses only 32 chips, less than one-fourth the number of components on some system boards. Many of these chips are VLSI devices from Chips & Technologies.

Four system ROM chips are situated on the left side of the system board. They are organized into 32-bit read-only memory that can be accessed with only one wait state inserted. A multipin connector on the front edge of the system board provides signals for SmartVu via a ribbon cable.

The connector in the center front of the system board is for the $386^{16}$'s static memory board (photo 6). The connector's location in the front of the board prevents the inadvertent installation of conventional boards or, worse yet, the installation of the static memory board in a conventional expansion slot. However, the front location requires extra care when mounting the memory board, because the connector is a considerable distance from the screwed-down mounting bracket at the rear of the system unit.

DIP switches on the memory board are changed to indicate total system memory as memory is added to the board (or as extended memory boards are added to the system).

The 16-MHz Intel 80386 sits on the lower right of the multilayer system board. Below the 386 is the optional 8-MHz 80287 math coprocessor, inexcusably located on the portion of the system board that lies buried under the hard-disk bay. Installation requires removing all expansion boards and the system board—not a task for the faint of heart. In most systems this inaccessible area is filled with keyboard chips or other components that the average user does not need to fool with. PC's Limited engineers should rethink this arrangement. Oddly enough, the sockets for the 286 and 287 in the PC's Limited $286^{12}$ are easily accessible.

Like the original Deskpro 386, the $386^{16}$ cannot use the 80387 math coprocessor. (Compaq now offers an optional 387 socket, as described in Product Watch, November 1987, p. 223.) This is an unfortunate omission; the much faster, but costlier, 387 will be missed by potential customers with number-crunching in mind.

The $386^{16}$ has seven AT-compatible expansion slots—two 8-bit and five 16-bit slots—in addition to the special 32-bit memory board slot. The machine comes standard with three of its expansion slots already filled.

The two 8-bit slots on the left are occupied by the graphics adapter and multifunction I/O adapter. The switches for configuring the graphics adapter are on its mounting bracket and are accessible from the rear of the system unit without removing the cover.

The multifunction I/O adapter is a short card, as is the graphics adapter. It is compatible with the AT serial/parallel adapter, and has the usual 9-pin and 25-pin connectors on its end bracket. A cable and mounting bracket for the second serial port's 25-pin D-shell connector are provided; use of the mounting bracket for the second serial port reduces the number of available expansion slots by one (to a total of three on the 40MB or 70MB model and just two on the 150MB model).

DIP switches on the multifunction board allow the primary and secondary serial ports to be designated COM1 and COM2, or COM2 and COM3, or COM3 and COM4, respectively. Switch settings also determine which interrupt level

## TABLE 1: *Disk Drives Supported*

| DRIVE TYPE | NUMBER OF CYLINDERS | NUMBER OF HEADS | SECTORS/TRACK | CAPACITY (MB) |
|---|---|---|---|---|
| 0 | No hard disk | | | |
| 1 | 306 | 4 | 17 | 10 |
| 2 | 615 | 4 | 17 | 20 |
| 3 | 615 | 6 | 17 | 30 |
| 4 | 940 | 8 | 17 | 62 |
| 5 | 940 | 6 | 17 | 46 |
| 6 | 615 | 4 | 17 | 20 |
| 7 | 462 | 8 | 17 | 30 |
| 8 | 733 | 5 | 17 | 30 |
| 9 | 900 | 15 | 17 | 112 |
| 10 | 820 | 3 | 17 | 20 |
| 11 | 855 | 5 | 17 | 35 |
| 12 | 855 | 7 | 17 | 49 |
| 13 | 306 | 8 | 17 | 20 |
| 14 | 733 | 7 | 17 | 42 |
| 15 | Reserved | | | |
| 16 | 612 | 4 | 17 | 20 |
| 17 | 977 | 5 | 17 | 40 |
| 18 | 977 | 7 | 17 | 56 |
| 19 | 1,024 | 7 | 17 | 59 |
| 20 | 733 | 5 | 17 | 30 |
| 21 | 733 | 7 | 17 | 42 |
| 22 | 733 | 5 | 17 | 30 |
| 23 | 306 | 4 | 17 | 10 |
| 24 | 830 | 10 | 17 | 68 |
| 25 | 1,024 | 9 | 17 | 76 |
| 26 | 918 | 7 | 17 | 53 |
| 27 | 1,024 | 8 | 17 | 68 |
| 28 | 918 | 11 | 17 | 83 |
| 29 | 1,024 | 4 | 17 | 34 |
| 30 | 820 | 6 | 17 | 40 |
| 31 | 969 | 9 | 34 | 144 |
| 32 | 615 | 8 | 17 | 40 |
| 33 | 1,024 | 5 | 17 | 42 |
| 34 | 1,024 | 15 | 17 | 127 |
| 35 | 1,024 | 15 | 26 | 195 |
| 36 | 1,024 | 8 | 26 | 104 |

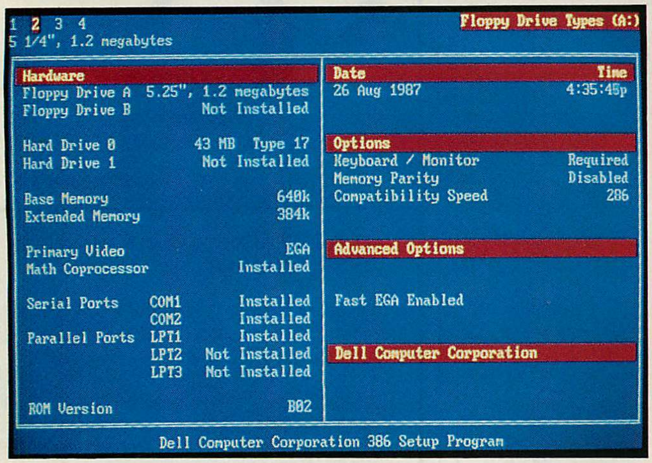
**The system's BIOS supports the 22 hard-disk drive types supported by the IBM AT (with the same type numbers), plus an additional 13 types (numbers 24–36).**

each port uses; the choices are IRQ2, 3, 4, or 5. The ports may be enabled or disabled individually, and each port has designated jumpers that allow signals such as clear-to-send (CTS), data set ready (DSR), and data carrier detect (CD) to be "forced true." Ports and interrupt levels can likewise be selected for the parallel port, and it can be enabled or disabled by a switch setting. The game port uses I/O port address 200H-207H and can be enabled or disabled by setting a DIP switch.

One of the five 16-bit expansion slots houses the standard Western Digital WD1003-WA2 diskette-drive and hard-disk controller, which controls the system's 40MB hard disk and 1.2MB diskette drive. Although only three different sizes of hard disks are offered as standard equipment on the system, the BIOS supports 35 drive types, which are listed in table 1.

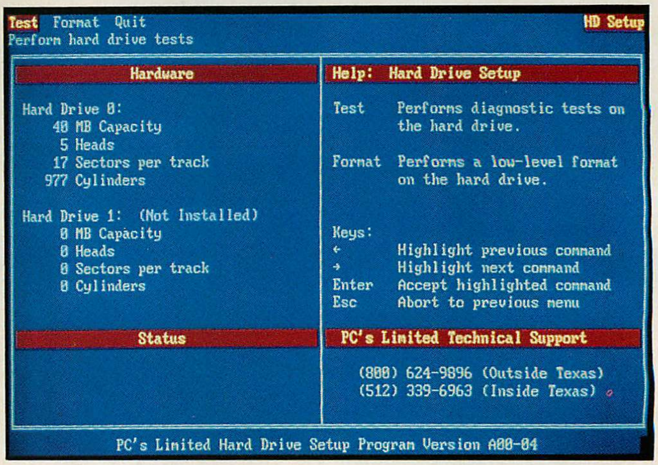
Cables are provided for the connection of two diskette and two hard-disk drives. The only cable not provided is the 20-pin data cable for connecting the second hard drive, and that is usually supplied with the drive. The 150MB model features an ESDI hard-drive controller, which takes up an additional expansion slot. The 200-watt power supply provides power connectors for a total of four drives.

**PHOTO 7:** *Set-up Screen*




The ROM-resident set-up utility is as easy to use as it is close at hand. All settings and options are displayed as a single menu screen. This way, the user can make changes more directly than with the AT's separate set-up utility.

**PHOTO 8:** *Hard-disk Utility*




The comprehensive hard-disk utility allows menu-driven set-up and testing of a wide variety of hard disks. Accompanying documentation provides complete information on the physical installation of any hard disk likely to be used.

Both the hard-disk and diskette drives are mounted using rails that are not compatible with those used on the AT. They are held in place by screws inserted into the side of each bay, rather than by the front-mounted fasteners used with the AT and most compatibles. This makes the installation of devices in the left bay problematic in that all the full-length expansion boards have to be removed in order to gain access to the side mounting screws.

Expansion boards are held in place by a six-inch-long metal plate, called the security bracket, which is installed over the top front of all the boards. The security bracket is secured to the case with one-quarter-inch screws like those that hold the system case and board-mounting brackets; thus, board swapping is possible using only one nut driver.

The system speaker and the battery that maintains the system's CMOS configuration memory are mounted in the space directly below the expansion board security bracket.

## BUILT-IN SET-UP

PC's Limited believes in keeping the set-up program at the user's fingertips; therefore, unlike IBM and Compaq, which supply separate set-up diskettes with their machines, PC's Limited computers store the set-up program in ROM. The company configures each system before it goes out, so if no user options are to be added, set-up merely involves loading software.

If new equipment is to be added, however, the user invokes the set-up program by pressing Ctrl-Alt-Enter; this brings up the screen shown in photo 7. The main menu sits on the top line, and submenu options appear on the second line. The first category on the main menu, **equipment**, is used for selecting disk drives, graphics adapter, and math coprocessor.

The next selection, **options**, can be used to allow booting without a keyboard or monitor attached, to enable memory parity checking if DRAM expansion boards are installed, to set the

system's compatibility speed to emulate either an 8088 or 80286 computer, or to select advanced options. Advanced options include setting the expansion bus speed to 8 or 12 MHz, enabling DRAM refresh if DRAM boards are installed, and disabling fast EGA mode if your combination of software and graphics adapter do not support it.

Other main menu selections include setting the date and time and parking the hard-disk heads. A **help** option provides a list of error codes, precautions when selecting advanced options, and a list of PC's Limited telephone numbers for customer support. A **boot** option resets the system without having to turn it off and puts into effect any changes in hardware configuration. The **quit** selection returns the control to the current application; however, the application's screen contents are not saved and restored.

## BAGS OF GOODIES

With each $386^{16}$ machine come several plastic bags filled with software and documentation. Among the contents are utilities for installing and configuring hard disks (see photo 8). The *Hard-drive Product User's Guide* will prove indispensable to the systems integrator. The 166-page manual includes detailed instructions for connecting virtually any disk drive and controller likely to be used on the $386^{16}$ or other compatible system. A separate package allows a hard disk to be split into multiple volumes, a standard feature of DOS 3.3.

PC's Limited offers MS-DOS 3.2 and BASIC at additional cost. MS-DOS features the RAM-disk driver program, RAMDRIVE.SYS, which unlike IBM's VDISK.SYS (included with PC-DOS) can use expanded as well as extended or conventional memory to emulate a disk drive. PC's Limited does not provide a diagnostics diskette, although this omission is offset somewhat by the realtime error codes that are reported on the SmartVu display; however, the system cannot be manually tested for diagnostic or reliability purposes.

Documentation for the $386^{16}$ is clear and complete, consisting of the spiral-bound *Owner's Manual* and *Hard-drive Product User's Guide*, and pamphlets describing the hard-drive set-up utility, the split-drive utility, and the multifunction I/O card. All manuals are illustrated with helpful diagrams; none has an index, but the table of contents in each is thorough.

PC's Limited is particularly sensitive to the subject of customer support, having suffered considerable criticism for inadequate service in the past. The company is anxious to convince customers that a direct-marketing organization can provide good support. Because its computers are sold directly to the customer, users cannot run to their nearest dealer whenever a problem crops up. PC's Limited provides buyers with a support package consisting of toll-free telephone assistance (open 7 a.m. to 7 p.m. central time) and a 12-month, on-site service contract with Honeywell Bull. The service contract provides next-day service for any customer who is located within 100 miles of a Honeywell Bull facility, of which there are 198 (covering 95 percent of the continental United States, according to PC's Limited).

*The $386^{16}$'s SRAM chips offer more consistently fast performance than the memory access methods used by other 386 machines.*

A maintenance call placed during the course of testing the $386^{16}$ for this review bore out PC's Limited's claim of next-day service. A trained Honeywell Bull representative arrived at the editorial offices within 24 hours of the call.

PC's Limited also includes a one-year limited warranty under which the company will repair or replace, at its option, defective parts; the product must be shipped at the customer's expense to the factory in Austin, Texas, following explicit instructions supplied by PC's Limited.

## MEASURING PERFORMANCE

As is standard operating procedure throughout *PC Tech Journal*'s "Compatibility and Performance" series, the PC's Limited $386^{16}$ was put through two phases of testing: the first phase checked for IBM-standard compatibility by installing specific third-party hardware and software; the second set of tests consisted of the *PC Tech Journal* Evaluation Suite. (For a complete explanation of the testing procedures, see "Out from the Shadow of IBM," Steven Armbrust, Ted Forgeron, and Paul Pierce, August 1986, p. 52, and "Updating the Evaluation Suite," Ted Forgeron, Paul Pierce, and Steven Armbrust, March 1987, p. 70.)

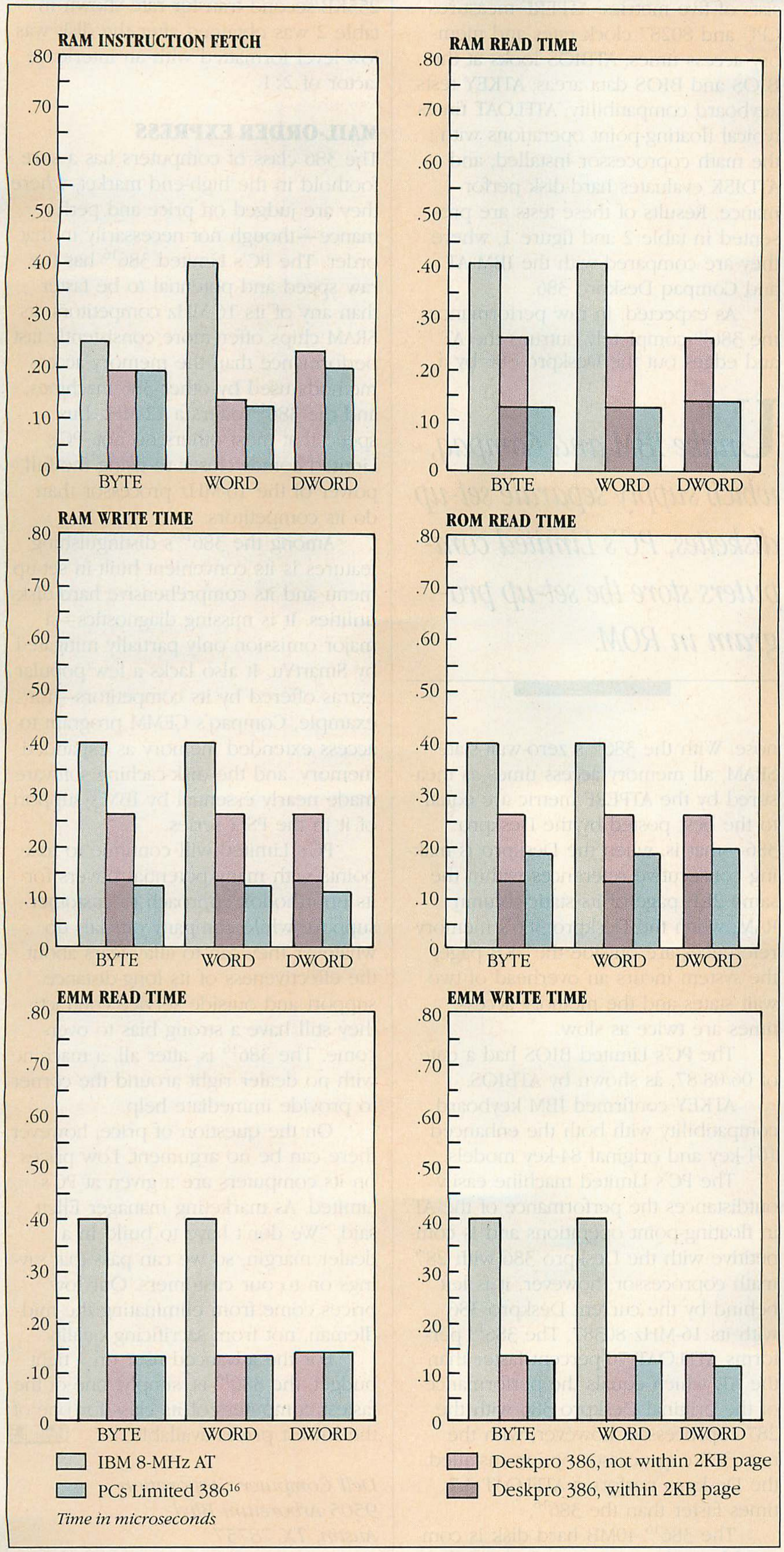
## TABLE 2: *Compatibility and Performance Tests*

| | 8-MHz AT, 30MB DISK[a] | DESKPRO 386, 40MB DISK, 80387 | PC'S LIMITED 386[16] 40MB DISK |
|---|---|---|---|
| **ATBIOS** | | | |
| ROM BIOS date | 11/15/85 | 04/27/87 | 06/08/87 |
| **ATPERF** | | | |
| Average RAM instruction fetch ($\mu$s) | | | |
| BYTE | .25 | .19 (130)[b] | .19 (130) |
| WORD | .403 | .14 (280) | .13 (305) |
| DWORD | N/A | .23 | .21 |
| Average RAM read time ($\mu$s)[c] | | | |
| BYTE | .401 | .13/.26 (298/154) | .13 (303) |
| WORD | .401 | .13/.26 (298/154) | .13 (303) |
| DWORD | N/A | .14/.26 | .14 |
| Average RAM write time ($\mu$s)[c] | | | |
| BYTE | .401 | .13/.26 (307/154) | .12 (338) |
| WORD | .401 | .13/.26 (307/154) | .12 (338) |
| DWORD | N/A | .13/.26 | .11 |
| Average ROM read time ($\mu$s) | | | |
| BYTE | .401 | Same as RAM read | .19 (206) |
| WORD | .401 | Same as RAM read | .19 (206) |
| DWORD | N/A | Same as RAM read | .20 |
| Average CGA video write time ($\mu$s) | | | |
| BYTE | 1.208 | 1.21 (100) | 2.23 (54) |
| WORD | 2.415 | 2.42 (100) | 3.35 (72) |
| DWORD | N/A | 4.83 | 5.59 |
| Average EMM read time ($\mu$s) | | | |
| BYTE | .402 | .13 (301)[d] | .13 (301)[e] |
| WORD | .402 | .13 (301) | .13 (301) |
| DWORD | N/A | .14 | .14 |
| Average EMM write time ($\mu$s) | | | |
| BYTE | .402 | .13 (306)[d] | .12 (338)[e] |
| WORD | .402 | .13 (306) | .12 (338) |
| DWORD | N/A | .13 | .11 |
| CPU clock rate (MHz) | 8.0 | 16.0 (200) | 16.0 (200) |
| Math coprocessor clock rate (MHz) | 5.3 | 16.0 (300) | 8.0 (150) |
| Refresh overhead (%) | 7.1 | 15 | 5.9 |
| RAM read/write wait states | 1/1 | 0/0 | 0/0 |
| ROM read wait states | 1 | Same as RAM read | 1 |
| Video write wait states (CGA) | 8 | 17 | 51 |
| EMM read/write wait states | 1/1 | 0/0[d] | 0/0[e] |
| **ATFLOAT** | | | |
| Performance as percentage relative to AT | 100 | 630 | 170 |
| **ATDISK** | | | |
| Sectors/track | 17 | 17 | 17 |
| Heads | 5 | 5 | 5 |
| Cylinders | 731 | 978 | 975 |
| Total space (million bytes) | 31.81 | 42.56 | 42.4 |
| Track-to-track seek time (ms) | 6.0 | 4.2 | 4.4 |
| Average seek time (ms) | 37.1 | 26.8 | 26.5 |
| Effective transfer rate (KB/sec) | 170.1 | 255.0 | 255.0 |
| DOS file I/O (sec) | 7.3 | 7.4 | 6.2 |
| Interleave | 3 | 2 | 2 |

[a] *The figures for the IBM PC/AT and Compaq Deskpro 386 are the average results from several machines, whereas the results from the PC's Limited 386[16] are taken only from the review sample model.*
[b] *Figures that are shown in parentheses represent the machine's relative performance expressed as a percentage compared to* PC Tech Journal*'s baseline machine, the 8-MHz, 30MB AT.*
[c] *For the Deskpro 386, the first number is for memory access within the same 2KB page; the second is for access not within the same 2KB page.*
[d] *EMM measurements were taken using the Deskpro 386's built-in memory configured as expanded memory with the CEMM driver.*
[e] *EMM measurements were taken using the 386[16]'s 384KB of extended memory as expanded memory using Quarterdeck's QEMM driver.*

System performance of the PC's Limited 386[16] is uniformly fast. Its 16-MHz processor is well matched with its 32-bit zero-wait-state static RAM and one-wait-state ROM. The only slow component is the 8-MHz 80287 math coprocessor.

## FIGURE 1: *Performance Comparison*




**The 386[16] completely eclipses the performances of the 8-MHz AT, and with its static RAM it leaves the Deskpro 386 behind when the Deskpro is accessing memory that is not in the same 2KB page of Compaq's static-column RAM.**

All of the hardware products tested in the 386[16] worked correctly. They included the 80287 math coprocessor, Microsoft serial and bus mice, IBM Enhanced Graphics Adapter, Intel Above Board with 4MB, Hayes Smartmodem 1200B, IBM Game Adapter, and the Cheetah memory card.

All expansion boards tested worked properly with the expansion bus operations at 12 MHz as well as at 8 MHz. Only the Above Board 286 (which is designed to operate at bus speeds up to 12.5 MHz) demonstrated increased performance when used in 12-MHz mode, showing about a 25-percent increase in performance.

Testing with the Above Board revealed an interesting feature of the system's memory architecture. As mentioned earlier, the 386[16] comes standard with 1MB of SRAM, 384KB of which is configured as extended memory beginning at 1MB. When an additional 1MB of SRAM is added to the system, a total of 1.384MB of extended memory results. Some memory boards such as the Intel Above Board can provide extended memory only on a .5MB address boundary. Therefore, when adding extended memory using such a board, the board's extended memory starting address must be set to 1MB in order to avoid a gap in the extended memory address space.

In this case, because memory on the static memory board has priority over memory installed in the expansion bus, references to the first 384KB of extended memory are made to the SRAM memory, and the first 384KB of memory on the expansion memory board is not accessible as extended memory. On an Above Board, however, this memory is automatically accessible as expanded memory.

No problems were encountered with any of the software that was used to test the 386[16]. The software included Microsoft Windows 1.04 and Word 3.11 to test graphics capabilities; Borland's SideKick 1.56A, SuperKey 1.16A, and Turbo Lightning 1.01A to test memory-resident programs; Living Videotext's Ready! 1.00E and Intel's QUIKMEM 1.0 to test expanded memory; Hayes Smartcom II 2.2 and DCA/Crosstalk Communications' Crosstalk XVI 3.61 to test telecommunications abilities with the Hayes Smartmodem installed; and Fifth Generation Systems' Fastback to test direct memory access.

IBM's SETUP was used successfully to change standard features; IBM's VDISK 3.2 and MS-DOS's RAMDRIVE 1.19 ran without problem.

The second phase of testing, the *PC Tech Journal* Evaluation Suite, consists of five metrics: ATPERF measures CPU and 80287 clock rates and memory access times; ATBIOS looks at the BIOS and BIOS data areas; ATKEY tests keyboard compatibility; ATFLOAT times typical floating-point operations with the math coprocessor installed; and ATDISK evaluates hard-disk performance. Results of these tests are presented in table 2 and figure 1, where they are compared with the IBM AT and Compaq Deskpro 386.

As expected, in raw performance, the $386^{16}$ completely outruns the AT and edges out the Deskpro 386 by a nose. With the $386^{16}$'s zero-wait-state SRAM, all memory access times as measured by the ATPERF metric are equal to the best posted by the Deskpro 386—that is, when the Deskpro is making consecutive references within the same 2KB page of its static-column RAM; when the Deskpro 386's memory references are outside the 2KB page, the system incurs an overhead of two wait states and the memory access times are twice as slow.

*Unlike IBM and Compaq, which supply separate set-up diskettes, PC's Limited computers store the set-up program in ROM.*

The PC's Limited BIOS had a date of 06/08/87, as shown by ATBIOS.

ATKEY confirmed IBM keyboard compatibility with both the enhanced 101-key and original 84-key models.

The PC's Limited machine easily outdistances the performance of the AT in floating-point operations and is competitive with the Deskpro 386 with 287 math coprocessor; however, it is left behind by the current Deskpro 386 with its 16-MHz 80387. The $386^{16}$ performs ATFLOAT 70-percent faster than the AT, which equals the performance of the original Deskpro 386 with the 287 coprocessor; however, with the new 387 coprocessor option installed, the Deskpro performs ATFLOAT 3.7 times faster than the $386^{16}$.

The $386^{16}$ 40MB hard disk is comparable to that of the Deskpro 386; on the DOS file I/O test, the Compaq disk performed slightly better. The disk on the review unit was already formatted with a 3:1 interleave factor. The 255KB/second transfer rate shown in table 2 was obtained after the disk was low-level formatted with an interleave factor of 2:1.

## MAIL-ORDER EXPRESS

The 386 class of computers has a sure foothold in the high-end market, where they are judged on price and performance—though not necessarily in that order. The PC's Limited $386^{16}$ has the raw speed and potential to be faster than any of its 16-MHz competitors; its SRAM chips offer more consistently fast performance than the memory access methods used by other 386 machines, and the $386^{16}$ offers a 12-MHz bus speed that most others do not. PC's Limited comes closer to using the full power of the 16-MHz processor than do its competitors.

Among the $386^{16}$'s distinguishing features is its convenient built-in set-up menu and its comprehensive hard-disk utilities. It is missing diagnostics—a major omission only partially mitigated by SmartVu. It also lacks a few popular extras offered by its competitors—for example, Compaq's CEMM program to access extended memory as expanded memory, and the disk-caching software made nearly essential by IBM's support of it in the PS/2 series.

PC's Limited will continue to lose points with many potential buyers for its unorthodox approach to customer support; while company officials do whatever they can to allay fears about the effectiveness of its long-distance support and outside service contract, they still have a strong bias to overcome. The $386^{16}$ is, after all, a machine with no dealer right around the corner to provide immediate help.

On the question of price, however, there can be no argument. Low prices on its computers are a given at PC's Limited. As marketing manager Ellett said, "We don't have to build in a dealer margin, so we can pass that savings on to our customers. Our low prices come from eliminating the middleman, not from sacrificing quality."

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# Part 1
# Designing Drivers

*Now that the ground rules have changed, customizing device drivers will be a far more complex task than it was in the days of DOS.*

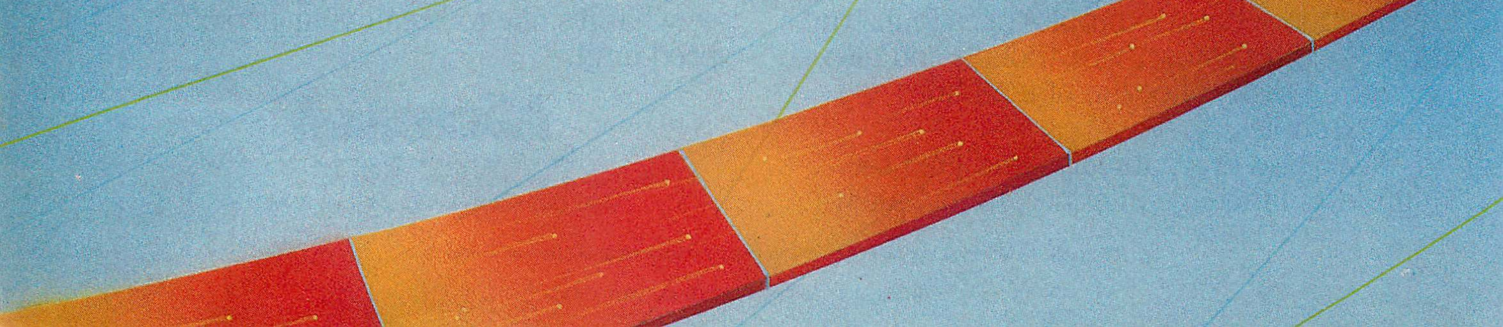
DAVID A. SCHMITT

OS/2 is a powerful operating system with enough features to satisfy any user . . . well, almost any user. One group—applications developers—may well need features that OS/2 does *not* provide, or hardware that OS/2 does not support. For them, the solution is to design their own OS/2 device drivers.

To help in this task, OS/2 offers them a modular, layered design that allows for the replacement or the addition of functional modules at several levels. (For details about which components can be replaced, refer to "An Architecture for the Future," Martin Heller, November 1987, p. 66).

Device drivers are a vital layer in this structure. As in DOS and UNIX, they isolate the operating system kernel and application programs from the vagaries of physical devices, making it relatively easy to install the operating system on a wide variety of hardware configurations. Only the device driver needs to know the I/O addresses of a device controller or a disk drive's physical dimensions, such as its number of heads, tracks, or sectors. To the rest of the system, however, the driver *becomes* the device, presenting a standard interface to the application programs, regardless of any of the underlying physical characteristics.

The problem is that designing a driver for OS/2 is a far more complex job than developing one for DOS. Although DOS and OS/2 drivers have similar functions and architecture, OS/2 drivers must support multitasking and also must be able to operate in both protected and real modes. Because the I/O in OS/2 can be asynchronous, allowing an application to continue executing while an I/O operation is in progress, the operating mode in use when an I/O request is initiated can differ from the mode in use when it terminates. In general, OS/2 drivers also cannot use the ROM BIOS routines that provide the lowest level of interface to devices, because these routines



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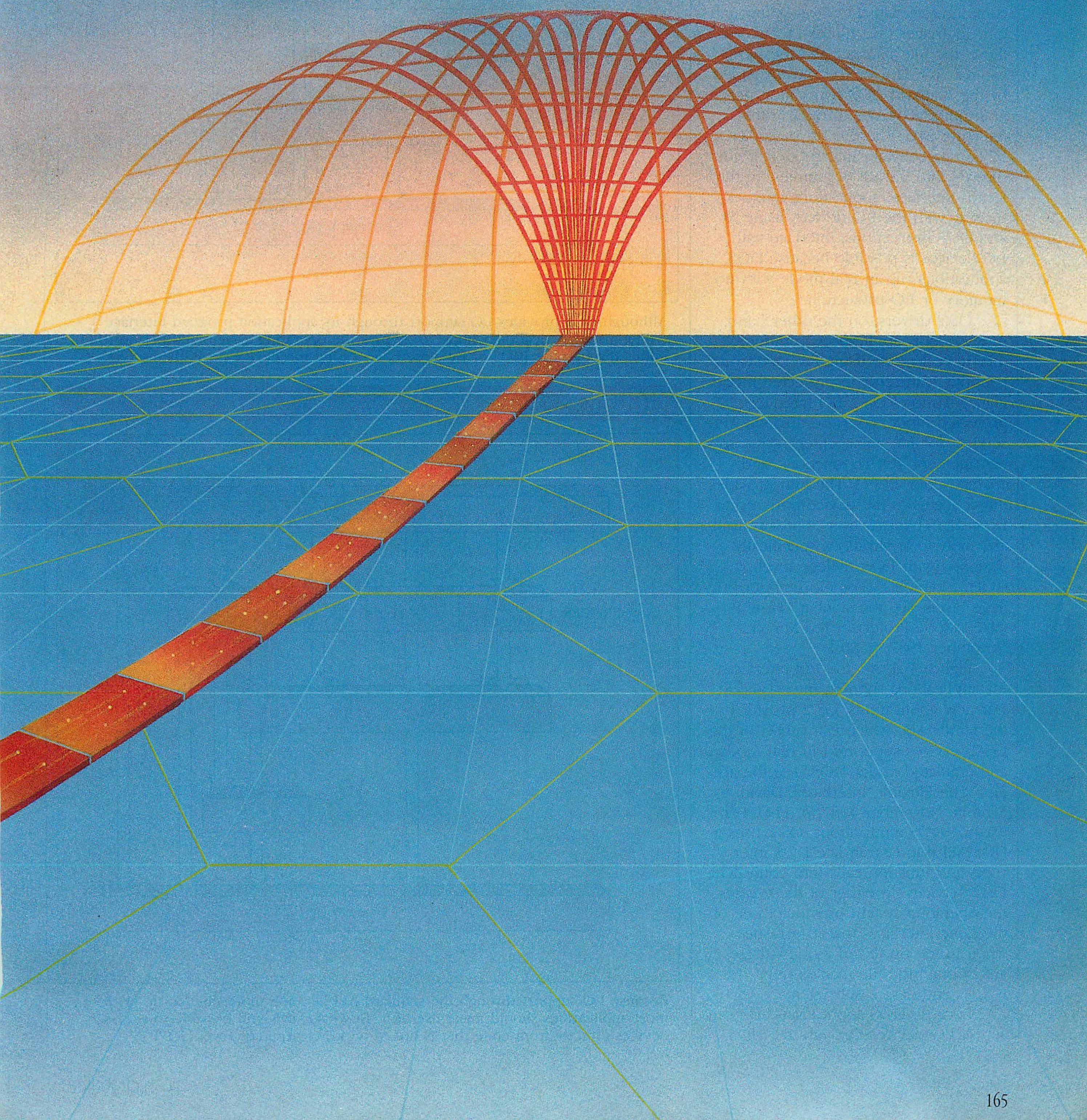
for OS/2



are written for operating in real mode only. Instead, for the most part, the drivers themselves must be programmed down to the hardware level.

This overview of the design and structure of OS/2 device drivers also compares OS/2 drivers with DOS device drivers. A subsequent article will detail the specifics of creating a working character device driver.

**I/O ARCHITECTURE**

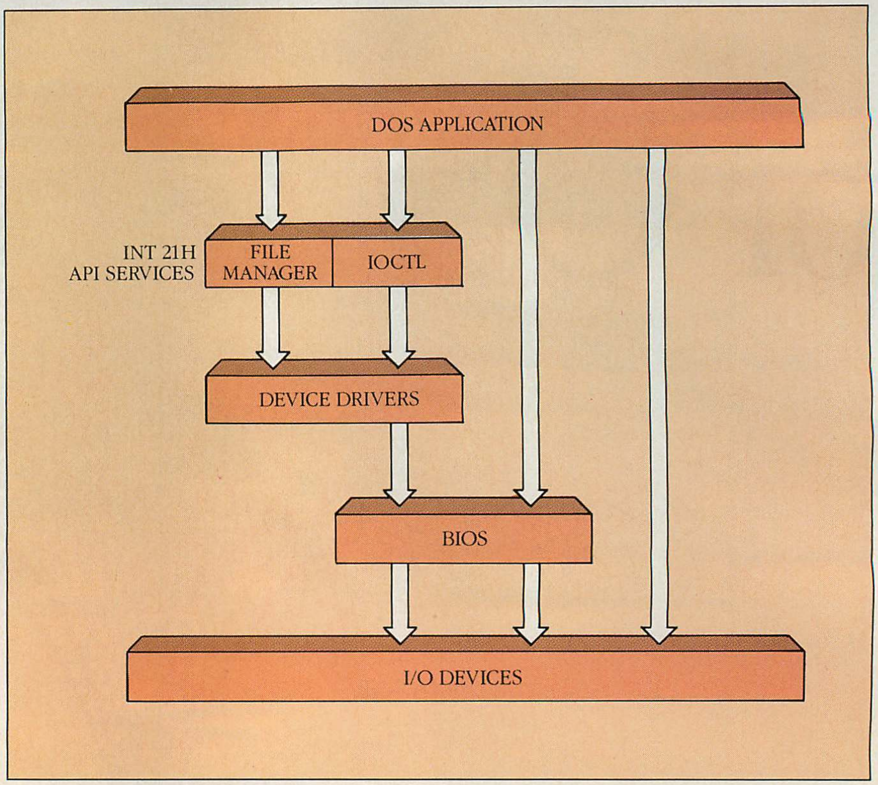
The complexity of OS/2 becomes evident when its architecture is compared with that of DOS. DOS applications communicate with I/O devices through four interfaces (see figure 1). Two of these, the file manager and the I/O control (IOCTL) services, are provided by the standard DOS application program interface (API) through software interrupt 21H. The third bypasses DOS by issuing software interrupts that go directly into the BIOS routines. In the fourth interface, applications interact directly with the I/O devices using IN and OUT instructions; interface with I/O devices is possible because DOS applications run in real mode with no memory or I/O protection.

OS/2 drivers, on the other hand, must support applications running either in real mode using the DOS compatibility feature or in protected mode. Figure 2 shows OS/2 I/O interfaces in protected mode. Four are through API services for file management, session management, IOCTL functions, and character device I/O. The fifth provides direct access to the device ports using IN and OUT instructions, but it is available only to applications specifically designed with I/O privilege level (IOPL) segments. (For more about privilege levels, see the sidebar "How Protected Mode Protects," Ted Mirecki, November 1987, p. 80.)

Figure 3 shows the I/O interfaces for applications running in real mode. For new applications, OS/2 provides the family API, which is a subset of the OS/2 services supported in real mode and emulated under DOS (see the article, "The Flexible Interface," David A. Schmitt, November 1987, p. 110). For existing DOS applications, OS/2 uses a DOS API trap to translate DOS interrupts and function calls into equivalent OS/2 services. In either of these cases, the operating system provides three of the same interfaces that it furnishes when in the protected mode—these are through the file manager, the IOCTL, and device subsystems.

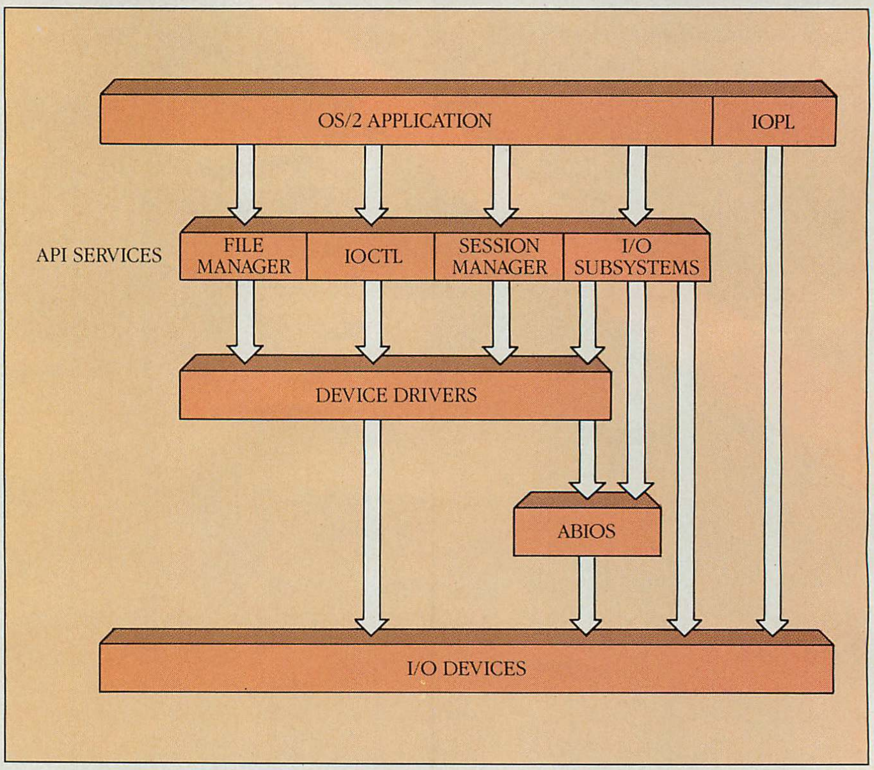
Because DOS applications also can access I/O devices through the BIOS

**FIGURE 1:** ***DOS I/O Interfaces***




Although DOS provides I/O support through its application program interface (API), many applications choose to bypass the operating system and perform I/O either through the BIOS or by directly accessing the device ports themselves.

**FIGURE 2:** ***OS/2 Protected-mode I/O Interfaces***




Because I/O support through the standard API is much more efficient in OS/2, most applications should make use of it. However, it is still possible to access devices directly from code that is linked with I/O privilege level (IOPL).

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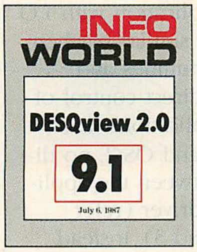


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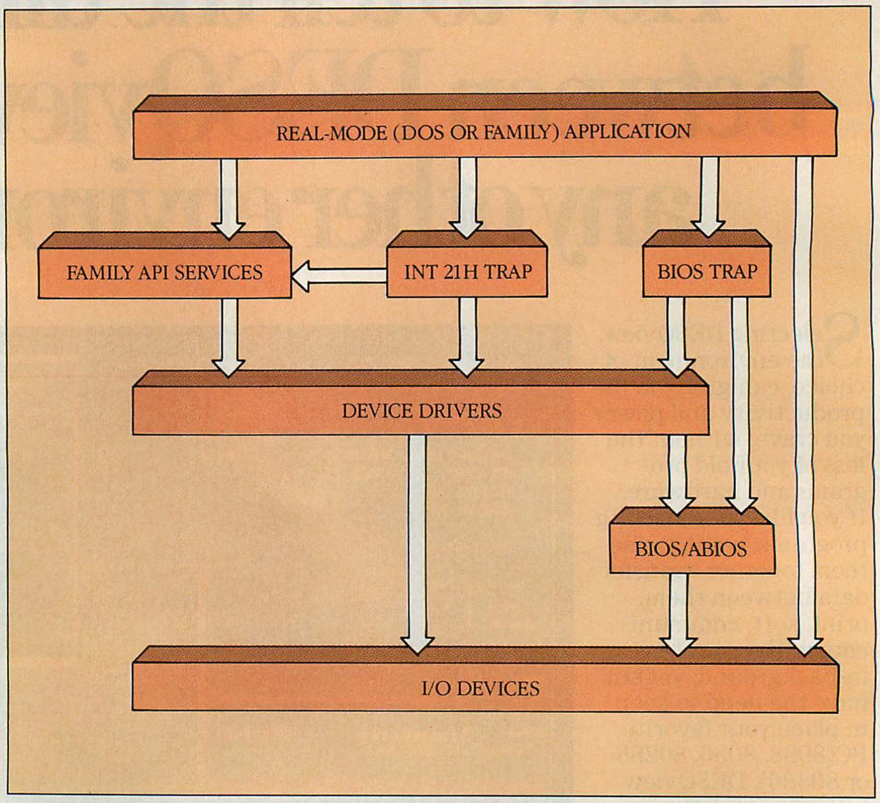
**FIGURE 3:** *OS/2 Real-mode I/O Interfaces*




OS/2 intercepts calls to DOS API and the BIOS, and reroutes them through the kernel into the device drivers. It allows real-mode programs to access ports directly for compatibility with the DOS applications that otherwise would not run.

interrupts, the OS/2 drivers must be able to hook into these interrupts in order to simulate the BIOS. For example, the screen driver must be able to attach to interrupt 10H and provide the appropriate BIOS video services.

Finally, because real-mode applications have I/O privileges intrinsically, these applications can access any device directly. Under DOS, you cannot really safeguard your driver from being disrupted if a DOS application decides to meddle with the devices that supposedly are under the driver's control. Of course, an OS/2 application with I/O privileges could create similar mayhem. OS/2 has all the opportunities and problems inherent in direct control of hardware from the applications level.

Under both DOS and OS/2, no direct interface exists between the application and the device driver (refer again to figures 1, 2, and 3). Instead, the application requests I/O services from the operating system by issuing API calls; only the operating system can call the driver. Because most driver calls are issued by the file manager and IOCTL, anyone designing a driver should know the characteristics of these two subsystems.

## FILE MANAGER

A strong file manager is a boon to driver designers, because it lets them concentrate on the intricacies of device control instead of having to worry about general issues, such as file sharing and device independence. The file manager implements the logical file structure of the operating system, and the driver deals with the physical disk layout. The file manager performs the following functions:

- Maintains a system of file names on each direct-access storage device (DASD) and keeps track of the location of each file.
- Allocates and releases space on the DASD media, as required by the application, and keeps track of the media space utilization.
- Translates file-relative block addresses into absolute-block addresses for the DASD driver. This gives the application a device-independent view of its file so that the file can be moved easily to a different type of DASD without affecting the application.
- Administers the file-sharing protocol among all the processes that are contending to have access to the same file simultaneously.

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Applications access the file manager through the general API service functions for opening, closing, reading, writing, and otherwise controlling files. These OS/2 services are a superset of the DOS fixed-memory address file services. The most significant new features, unavailable in DOS, are the asynchronous read-and-write functions that allow the calling process to continue to execute while the file manager and drivers carry out an I/O request.

The OS/2 file manager also preserves a useful DOS feature that can, in many cases, enable an application to be completely independent of the device. When you ask the file manager to open a file, it checks to see whether the file name is actually the name of some non-DASD device, such as a printer. If this is the case, the file manager routes all of the subsequent read-and-write requests to the driver for that device. As far as the application is concerned, the device looks just like a disk file. The OS/2 file manager provides the same sharing protocol for these devices as it does for DASD files.



### IOCTL INTERFACE

Besides controlling the actual read-and-write operations requested by the file manager and other system components, device drivers must provide specific device-dependent operations. For example, the serial-port driver must furnish a way for applications to change transmission rates and other communication characteristics. Functions such as these are provided by the IOCTL interface.

The IOCTL interface is the most direct way for applications to communicate with device drivers, but even here the path is through the operating system API. In OS/2, the application calls the API function DosDevIOCtl, then passes it the handle of an open file or device, a function code, and pointers to data for that function. The kernel, in turn, calls the driver for that device, passing it the parameters from the application. OS/2 provides more than 100 IOCTL functions; these include all of the IOCTL services available under DOS, some services performed in DOS by BIOS calls or direct access to the hardware, plus many more that are entirely new.

In designing a driver, you will need to handle the services that are appropriate for your device. If the device is really unusual, you may even need to invent some new IOCTL codes. Of course, only applications written with knowledge of these new codes can take advantage of the new services.

### BIOS AND ABIOS

In DOS, device drivers can use ROM BIOS routines to perform the lowest level of device control. For example, a disk driver typically calls BIOS interrupt 13H instead of directly accessing the disk controller ports to perform the actual disk operations. This significantly simplifies DOS driver design. All DOS systems claiming compatibility with the IBM PC standard provide a BIOS that is functionally identical to the BIOS in an equivalent IBM machine; as a matter of fact, the degree to which the BIOS functions are identical is a primary measure of compatibility.

With OS/2, this carefully crafted BIOS-level compatibility is all for naught, because the ROM routines are written for execution in real mode only. Therefore, OS/2 device drivers must provide their own low-level device control coded for protected mode. At present, the only exception to this rule is the IBM PS/2 line, which has a set of protected-mode device-control routines called ABIOS (or advanced

BIOS). IBM's implementation of OS/2 for the PS/2 machines thus can incorporate simpler device drivers that make use of these routines.

A third-party designer of device drivers also can elect to write his drivers to use ABIOS, but that limits the drivers to PS/2 systems only. It remains to be seen whether the market for PS/2-style machines will develop to the point where it becomes economically feasible to clone ABIOS. It is technically feasible to do so, although not easy, because IBM does not publish the source code as it did for the AT BIOS. It even would be possible to retrofit existing AT-class machines, because the AT has an empty socket for an additional 64KB ROM chip addressed at segment E000H—which just happens to be the location of ABIOS in the PS/2. The standard BIOS on both ATs and PS/2s occupies 64KB at segment F000H.

For the foreseeable future, however, the only practical approach is to write drivers all the way down to the hardware level. It will be up to hardware manufacturers to provide RAM-resident drivers for their products, just as now they provide ROM-based BIOS drivers on disk controllers, video boards, network adapters, and the like.

**DEVICE TYPES**

OS/2, like DOS and *UNIX*, classifies devices and their drivers as either *block-oriented* or *character-oriented*. As the names imply, block devices transfer data in multibyte chunks (blocks), and character devices transfer just one byte at a time. Block-device transfers generally use direct-memory access (DMA); character devices use programmed I/O (PIO). With DMA, the driver tells the device where the block resides in memory and the device reads or writes that area without passing the data through the CPU. With PIO, the driver must execute an explicit I/O instruction for each byte being transferred. This tends to make character drivers much busier than block drivers.

Block drivers typically handle DASDs, such as fixed and removable disks; RAM disks; and optical storage units, such as CD-ROM and WORM (write once, read many). The term "direct access" refers to the device's ability to get directly from the current block to any other block in about the same amount of time. Block drivers also handle some sequential-access devices, most notably, magnetic tape units. Although you can reach any block on such a device, it may take a very long time because the device must sequentially pass over all blocks that are located between the current and the new positions.

Character drivers handle devices such as keyboards, printers, mice, and modems. This type of device typically sends or receives a serial stream of characters, in a fixed order—you cannot move backward or forward in the stream because it is transient within the device. The PC display screen also is treated as a character device, even though its memory buffer can be accessed directly and can be read or written to in any order.

This is a throwback to the days when most screens were in terminals that attached to their host computers by means of serial channels such as modems; it is still the general practice for minicomputers and mainframes. In fact, OS/2 and DOS both include a driver called ANSI.SYS that makes the PC screen behave just like an ANSI-standard display terminal; this feature is helpful when designing applications that must run on both the PC and on larger, multiuser computer systems.

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| Manual size/index | 250/No | 42/no | 469/Yes | 380/Yes |
| Benchmarks in 120K File: | | | | |
| 2000 replacements | 1:15 min | 34 sec | 1:07 min | 6 sec |
| Pattern matching search | 20 sec | Cannot | Cannot | 2 sec |
| Pattern matching replace | 2:40 min | Cannot | Cannot | 11 sec |


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**TABLE 1:** *OS/2 Character Device Names*

| DEVICE | DESCRIPTION |
|---|---|
| CLOCK$ | Time and date clock. |
| COM*x* | Serial port *x*—most implementations support three serial ports. |
| LPT*x* | Parallel port *x*—most implementations support three parallel ports. |
| PRN | A synonym for LPT1. |
| KBD$ | The keyboard—defined in protected mode only. |
| SCREEN$ | The display—defined in protected mode only. |
| CON | A synonym for KBD$ on input and SCREEN$ on output—defined in real and protected modes. |
| MOUSE$ | The mouse or other pointer device. |

OS/2 keeps all the familiar DOS device names and introduces several new ones. To help distinguish device names from file names, new device names end in $.

### DEVICE NAMES

Like DOS, OS/2 uses a system of names to refer to devices and to DASD files. In OS/2, this naming system has been extended so that applications can assign names to other resources such as *queues* and *semaphores* (see "Multiple Tasks," Steven Armbrust and Ted Forgeron, November 1987, p. 90). The file manager has overall control of this so-called *name space*. Nonetheless, when you design a driver, you must adhere to the various device naming conventions so that your driver will hook into the system correctly.

**Block device names.** Following the DOS convention, OS/2 designates each block device by a letter from A to Z; a block device is usually referred to as a *drive*, such as "drive A." The actual letter assigned to a particular device is not hard-coded in its driver, but is determined by OS/2 when it loads the driver during system initialization. The first block device is drive A, the second block device is B, and so on.

OS/2 follows the DOS convention that A and B are the two standard removable disk drives; these letters are assigned even if the system has only one removable drive. OS/2 also requires a fixed disk, and the first of these is always called drive C.

Assignments beyond C are governed by the contents of CONFIG.SYS, the configuration file. During initialization, OS/2 reads this file (just as in DOS) and assigns drive letters to the block devices. This leads to an interesting anomaly in both DOS and OS/2—two systems with an identical set of block devices can wind up with different drive-lettering schemes. The situation arises when the two CONFIG.SYS files specify the devices in different order. This anomaly can give users some nasty surprises when they move from one system to the other.

Because a block driver can be responsible for more than one device, the driver must tell OS/2 during system initialization how many drive letters should be assigned to it. This information is contained in the driver header.

**Character device names.** Each character device has a unique name, such as LPT1 or COM3, assigned by the driver designer and coded in the driver header. The standard OS/2 driver set includes the devices listed in table 1; most of these names are the same as in DOS. A programmer may write a driver for any of these devices; however, because the new driver will replace the standard one, it must provide the same services. Because processes internal to OS/2 will attempt to access these devices, any new drivers had better behave as OS/2 expects or else the system will then malfunction.

In addition, the OS/2 documentation warns that the developer should select device names that are not likely to conflict with disk file names—the file manager will not find a disk file if it has the same name as a device. As in DOS, when the file manager needs to open a file, it searches the device chain first and looks through the directory structure only if the specified name is not found. The recommended standard method to avoid this conflict is to place a dollar sign at the end of the device name, but this is a weak standard because disk file names also are allowed to include dollar signs.

### DRIVER ARCHITECTURE

An installable OS/2 driver resides on the disk as a standard .EXE format file produced by the linker. Its runtime code and data must conform to the small memory model, meaning that each driver is limited to a single code segment and a single data segment (no more than 64KB each).

The order in which segments appear in the load file is critical: the data segment must follow the header and precede the code segment. No stack segment is needed, because the operating system supplies a stack. However, the code segment can be followed by one or more additional segments, which are used only during initialization and are then discarded. These additional segments are necessary only if the segment containing the runtime code is so large that it leaves no room for initialization code.

Even though driver files use the .EXE format, it is customary to change the file extension from .EXE to something else, usually .SYS, .BIN, or .DEV. This prevents inadvertent attempts to execute drivers as commands. Although the OS/2 program loader can tell the difference and issues an error message, this could needlessly cause great confusion for the user.

As in DOS, OS/2 drivers are brought into memory via a special loader during system initialization as CONFIG.SYS is processed. Each driver is named in a device statement that specifies the name of the driver file and also can supply parameters for use by the driver in the course of its initialization phase. All of the device drivers are loaded into the lower 640KB of physical memory, so that they can be used both in the real mode as well as in the protected mode.

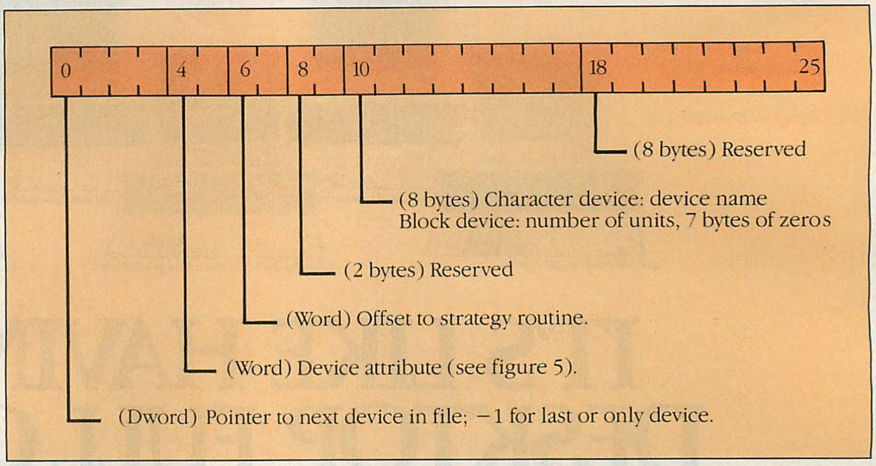
**DATA SEGMENT**

The driver data segment must immediately follow the EXE header so that the loader can find the driver header. The driver header must appear first in the data segment because it specifies fundamental information about the driver (for details, see figure 4).

The double-word pointer at the start of the header is used to link drivers into a chain. If the file defines drivers for more than one device, it points to the next header in the same data segment. The header for the last (or only) driver in the file must have a double-word value of −1. In the course of the system initialization, the loader uses the double-word pointer in order to hook the device drivers located in this file to the chain of drivers that are located in memory.

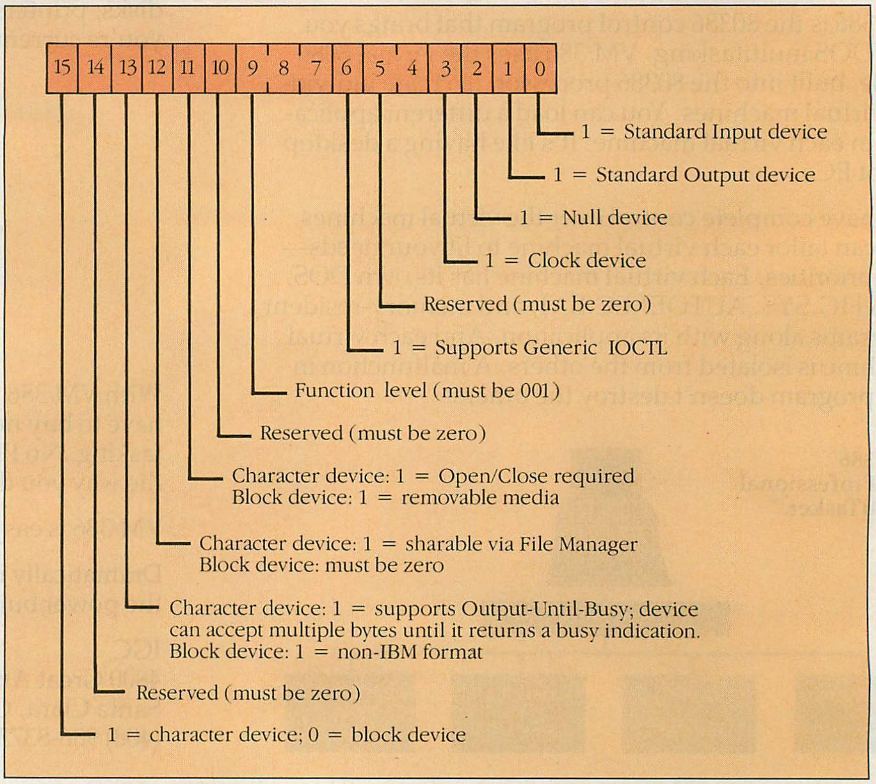
The device attribute word, which is shown in figure 5, contains flags and other values that specify some of the general characteristics of the driver, such as whether it is a character or a block device, whether it supports IOCTL functions, and so forth.

**FIGURE 4:** ***Device-driver Header***




**The device-driver header, kept at the start of a driver's data segment, defines the type and name of the device. The layout is essentially unchanged from DOS.**

**FIGURE 5:** ***Device Attribute Word***




**This field, carried in the device header, specifies the driver's characteristics. The bit definitions are very similar to the definitions encountered in DOS.**

For a character device, the eight-byte name field of the header contains the device name (for example, LPT1), left-justified and blank-filled. For a block device, the first byte contains the number of units that are supported; OS/2 assigns the next available drive letter for each unit. The other seven bytes are not used for a block device and should have a value of 0. Listing 1 and listing 2 (labeled DRIVER1.HDR and DRIVER2.HDR) constitute templates for the data segments of a single-device driver and those of a multiple-device driver, respectively.

**CODE SEGMENT**

The driver code segment can contain up to five major components: the strategy routine, handlers for device hardware interrupts, monitor support, BIOS interrupts from real-mode applications,

and timer interrupts. Every driver must have a strategy routine, and nearly all drivers will have at least one device hardware interrupt handler; monitor support, BIOS interrupts from real-mode applications, and timer interrupts are optional components.

**Strategy routine.** The strategy routine, which is usually the major part of the driver, executes as a privileged thread of the application process, running at privilege level 3, but with full I/O privilege. It is called by the kernel as it processes an application's I/O request. The kernel constructs a *driver request packet* in the low 640KB memory area and passes the packet pointer to the strategy routine. This packet specifies what operation the driver should perform. Some operations, such as initialization and status requests, can be handled immediately. When actual I/O is needed, the strategy routine either starts the operation using programmed I/O commands if the device is idle, or links the packet into a *device request queue* if the device is busy. Then it exits to the kernel without waiting for the I/O operation to complete or the device to become available.

One of the operations the kernel requests from the strategy routine is initialization. The kernel requests initialization only once, when the driver is loaded; it runs as a protected-mode task of the kernel. (This is the only time when the device driver can be sure of the CPU mode.)

**Device interrupt handler.** To improve multitasking performance, OS/2 drivers are expected to detect the completion of I/O operations using interrupts instead of wasting processor cycles in polling loops, the common practice in DOS drivers. For example, in DOS, after the ROM BIOS diskette routine starts an operation, it waits in an idle loop for the diskette controller to indicate completion by issuing interrupt EH. The handler for this interrupt merely sets a bit in memory that is tested by the diskette routine inside its own polling loop.

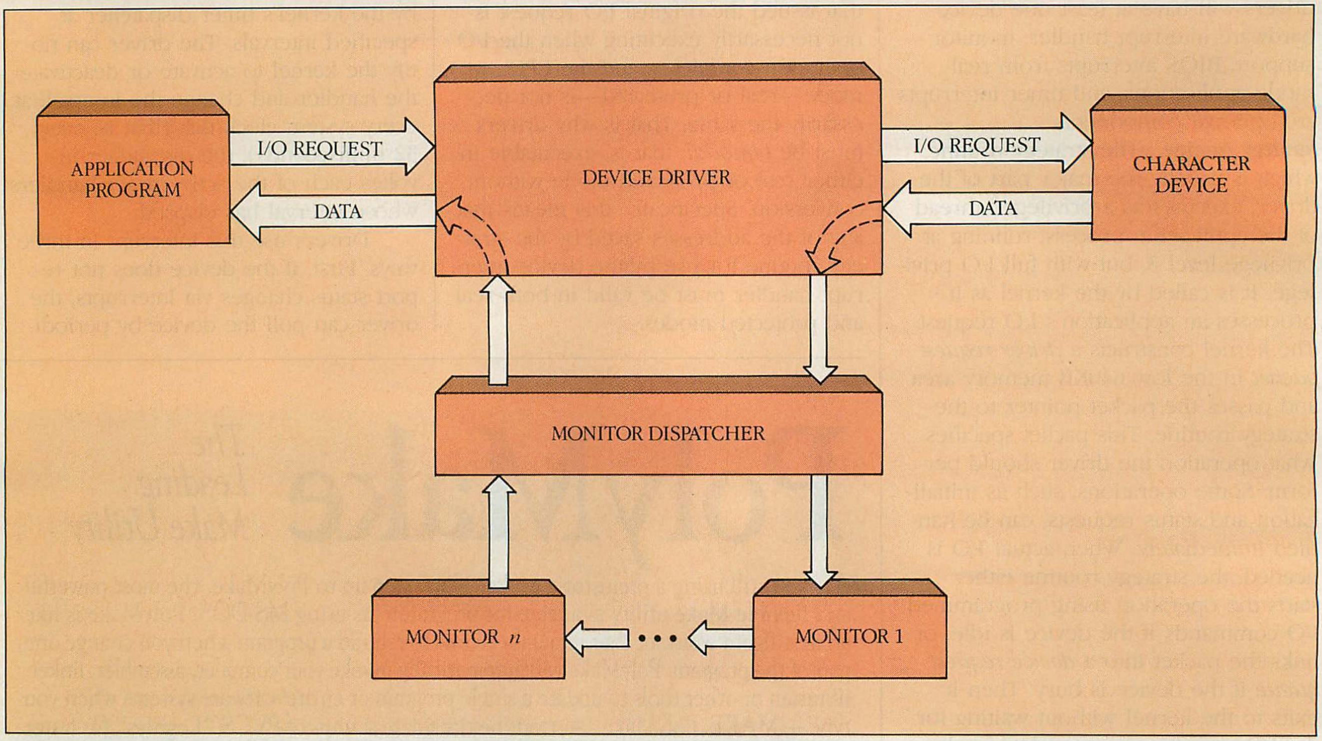
An OS/2 driver relinquishes control after its strategy routine has either started or queued up an I/O operation. The driver regains control at its device interrupt handler when the device issues a hardware interrupt indicating completion of that (or a previous) I/O operation. Then the driver performs whatever processing that is required in order for the I/O request to be completed, and restarts the device for the operation that is next in line in the request queue.

The device interrupt occurs asynchronously to any task. The task that issued the original I/O request is not necessarily executing when the I/O operation completes; and the CPU mode—real or protected—is not necessarily the same. That is why drivers must be *bimodal*, that is, executable in either real or protected mode without conversion. Specifically, this means that any of the addresses saved by the strategy routine for use by the device interrupt handler must be valid in both real and protected modes.

**Timer interrupt handler.** This is an optional driver component that is called by the kernel's timer dispatcher at specified intervals. The driver can notify the kernel to activate or deactivate the handler and change the interval; at every system clock tick (that is, every 32 milliseconds), the dispatcher invokes each of the active timer handlers whose interval has elapsed.

Drivers use this interrupt in three ways. First, if the device does not report status changes via interrupts, the driver can poll the device by periodi-

**FIGURE 6:** ***Driver-monitor Interface***




A device monitor examines each character passing through a driver. Although this figure shows data being input from a device, a monitor also can process output data. The driver controls registering of monitors and passing of characters into them.

cally checking its status in the timer interrupt handler. This method differs from the idle polling loop of DOS in that other tasks can run in the intervals between the timer interrupts.

Second, the timer interrupt can ensure that an I/O operation in an interrupt-driven device does not get hung up. For example, if the printer goes off-line while the driver is sending it a stream of characters, the "character received" interrupt will not occur, the device interrupt handler will not be entered, and the operation will stall. However, before initiating the data transfer operation, the driver can activate the timer to generate an interrupt some time after the transfer should be finished. If the operation completes successfully, the driver cancels the timing request; but if the timer interrupt occurs, the driver aborts data transfer and returns an error indicator.

Third, timer interrupts can be used to administer the device queue. In this case, the strategy routine does not communicate with the device but simply places each I/O request in the queue; the timer interrupt handler actually initiates the next I/O operation whenever the device is idle.

**BIOS interrupt handler.** This component is a requirement in any driver for a device that can be accessed from DOS applications through BIOS software interrupts. For example, DOS applications can access the printer via software interrupt 17H. Therefore, a printer driver must hook that interrupt so that it can translate the BIOS requests into I/O operations that work harmoniously with the OS/2 environment.

**Monitor support.** Character device drivers can support processes called *monitors* that can examine and possibly change the byte stream between the application and the device: a keyboard monitor, for example, can examine each keystroke before the driver passes it to the application currently reading the keyboard. This is the manner in which hot-key utilities and keyboard macro processors can be implemented in OS/2. A kernel component known as the *monitor dispatcher* manages the transactions that are taking place between the driver and the monitor.

The interface between a driver and its monitors is shown in figure 6. During initialization, the driver must establish monitor support by creating an empty monitor chain. An application process must call the general API function, DosMonReg, to "register" itself as a monitor for a device. The kernel passes this request via an IOCTL call to the driver, which hooks the process into the monitor chain. Then, as the driver receives each character, it hands off the character to the monitor dispatcher, which in turn passes it through each monitor in the chain. Any of these monitors can change, delete, or expand the character as it sees fit. Finally, the driver receives the last monitor's output, if any.

Passing data through a monitor does not automatically occur because the monitor has been registered; the monitor also must be explicitly coded into the device driver. In many device drivers, the monitor support is not really a separate component; instead, this is scattered throughout the strategy and interrupt routines.

## OPERATING MODES

The flow of control through the various components determines the operating mode or context in which the driver operates. When the strategy routine is executing an initialization request, the driver is operating in the *initialization mode*. When the kernel calls the strategy routine for any other operation, the driver is in the *kernel mode*. The driver is operating in *interrupt mode* when it is entered by means of a hardware or a timer interrupt; the driver operates in *user mode* when it is called from a real-mode application to process a BIOS interrupt.

**TABLE 2: *Device Helper Services***

| NAME | HEX CODE | WHEN USED[a] K | I | U | L | DESCRIPTION |
|---|---|---|---|---|---|---|
| SchedClock | 00 | | ● | | | Signal that clock tick occurred. |
| DevDone | 01 | ● | ● | | | Signal that I/O is complete. |
| Yield | 02 | ● | | | | Relinquish control. |
| TCYield | 03 | ● | | | | Yield to time-critical task. |
| Block | 04 | ● | | ● | | Block a thread from running. |
| Run | 05 | ● | ● | ● | | Release blocked thread. |
| SemRequest | 06 | ● | | ● | | Request a semaphore. |
| SemClear | 07 | ● | ● | ● | | Clear a semaphore. |
| SemHandle | 08 | ● | ● | | | Get a semaphore handle. |
| PushReqPacket | 09 | ● | | | | Link I/O request packet to queue. |
| PullReqPacket | 0A | ● | ● | | | Get next packet from queue. |
| PullParticular | 0B | ● | ● | | | Get specific packet. |
| SortReqPacket | 0C | ● | | | | Insert packet in sorted order. |
| AllocReqPacket | 0D | ● | | | | Get memory for a packet. |
| FreeReqPacket | 0E | ● | | | | Free allocated packet. |
| QueueInit | 0F | ● | ● | ● | | Initialize character queue. |
| QueueFlush | 10 | ● | ● | ● | | Flush characters from queue. |
| QueueWrite | 11 | ● | ● | ● | | Insert character in queue. |
| QueueRead | 12 | ● | ● | ● | | Read character from queue. |
| Lock | 13 | ● | | | ● | Lock down a memory segment. |
| Unlock | 14 | ● | | | ● | Unlock a memory segment. |
| PhysToVirt | 15 | ● | ● | | ● | Map physical to virtual address. |
| VirtToPhys | 16 | ● | | | ● | Map virtual to physical address. |
| PhysToUVirt | 17 | ● | | | | Map physical to user virtual address. |
| AllocPhys | 18 | ● | | | ● | Allocate physical memory. |
| FreePhys | 19 | ● | | | ● | Free physical memory. |
| SetROMVector | 1A | ● | | | ● | Set BIOS interrupt vector. |
| SetIRQ | 1B | ● | | | ● | Set hardware interrupt vector. |
| UnSetIRQ | 1C | ● | ● | | ● | Reset hardware interrupt vector. |
| SetTimer | 1D | ● | | | ● | Add event to timer list. |
| ResetTimer | 1E | ● | | | ● | Remove event from timer list. |
| MonitorCreate | 1F | ● | | | | Create empty chain of monitors. |
| Register | 20 | ● | | | | Add monitor to chain. |
| DeRegister | 21 | ● | | | | Remove monitor from chain. |
| MonWrite | 22 | ● | ● | ● | | Write data to monitor. |
| MonFlush | 23 | ● | | | | Flush data from monitor stream. |
| GetDOSVar | 24 | ● | | | ● | Get pointer to system information. |
| SendEvent | 25 | ● | ● | | | Indicate occurrence of event. |
| ROMCritSection | 26 | | | ● | | Enter/leave noninterruptible section. |
| PortUsage | 27 | ● | | | ● | Specify range of I/O addresses. |
| GrantPortAccess | 28 | ● | | | | Grant port access to application. |
| VerifyAccess | 29 | ● | | | | Verify legality of memory access. |
| EOI | 31 | | ● | | ● | Send end-of-interrupt to controller. |
| UnPhysToVirt | 32 | ● | ● | | ● | Release virtual mapping tables. |
| TickCount | 33 | ● | ● | ● | ● | Set timer interval. |

[a] *K = kernel mode, when strategy routine is executing. I = interrupt mode, when servicing device interrupt. U = user mode, when servicing BIOS interrupt. L = load time, during driver initialization.*

**DevHelps are a specialized set of operating system services available to device drivers. Except during initialization, drivers cannot call standard API services.**

The OS/2 documentation also uses another way to categorize execution in a driver. *Task time* is any execution that results from a task call, whether through an API call or a software interrupt; it includes the initialization, kernel, and user modes. *Interrupt time* is a driver entry caused by a hardware interrupt asynchronous to any task; it is synonymous with the interrupt mode.

The operating mode determines how the driver interacts with the operating-system kernel. In many instances, the various components of a driver might need operating system services, but a driver, in general, cannot use API calls because it is not an application-level program. The exception is in initialization mode, when the driver can call on a subset of the API services. In other modes, kernel services are provided by a library of routines known as *device helpers* (DevHelps). Table 2 lists these services and indicates the context in which each can be used.

DevHelps include two sets of services for managing two different types of queue. The first, codes 09H through 0EH, manages the queue of request packets waiting for the device. The second, codes 0FH through 12H, manages a circular queue that character device drivers can use to buffer data going to or coming from the device.

The interface to DevHelps is designed for assembly language. The device driver loads the service code into the DL register and other data specific to that service into other registers. It then issues an indirect far call to the DevHelp address obtained during initialization. With the exception of the registers used and the method of transferring control (far call instead of software interrupt), this interface is essentially the same as the DOS API.

### THROUGH THE FRONT DOOR

In OS/2, the strategy routine is the "front door" to the driver—most drivers remain idle until some process knocks on that door and passes in a request packet. Some packets just cause the strategy routine to perform internal bookkeeping, such as registering monitors or flushing input buffers. Others result in actual I/O interchanges with a device; in these cases, strategy routine must coordinate closely with timer and device interrupt handlers.

Some drivers also allow DOS applications to come in through the "side door"—through BIOS simulation; a real-mode application can request an I/O operation by issuing a BIOS interrupt. However, most drivers that support this feature are designed so that the BIOS interrupt handler ultimately passes control to the strategy routine. (The second article of this series will provide an example.)

The driver-request packet is used to pass information both to and from the driver. Each request packet begins with a 13-byte header, which may then be followed by a variable amount of data, up to 242 bytes, specific to the particular request (see figure 7). DOS uses the same general format for its drivers—the OS/2 designers have at-

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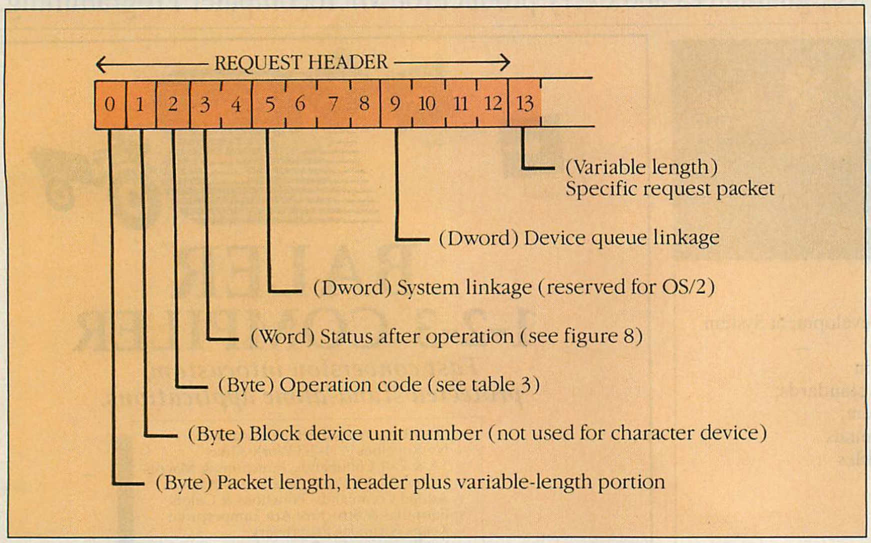
## FIGURE 7: *Driver Request Header*




**Each request from the kernel to the device driver consists of a 13-byte header followed by a variable-length field containing the data specific to the request.**

tempted to keep the specifics pretty much the same.

In the request packet's header, the kernel specifies the operation to be performed (see table 3), and, for block devices, the unit number (drive) on which the operation is to be performed. Upon completing the I/O request, the driver returns information about the operation in the header's status field (see figure 8). Device error codes, returned in the low-order byte of the status word, are listed in table 4. These errors are returned to the kernel, not the application program; the kernel can either handle the error itself, notify the application, or pop up a window to ask the user how to proceed—this is the OS/2 version of the well-known "Abort, Retry, Ignore" prompt returned by DOS.

The variable-length data area following the header also is used to pass information in both directions. Details of its layout and usage for each operation will be described in the next article, as required in order to describe the sample device driver.

The OS/2 kernel calls the strategy routine with a far call, passing the address of the request packet in ES:BX and either the segment address (in real mode) or the selector (in protected mode) of the driver's data segment in the DS register. These are the only registers that must be preserved. The strategy routine has full I/O privileges.

The SS:SP pair is a valid stack pointer; the stack must be returned in the same state that it was received. There is no documentation on the size of the stack passed to the strategy routine, or on how to switch to a larger one if necessary. But the default stack provided by the kernel appears to be entirely adequate, as long as it is used sparingly. In particular, a developer should avoid allocating large buffers on the stack; he should, instead, preallocate them in the data segment, or use the device helper services to allocate the buffers dynamically.

The strategy routine cannot be preempted by other *threads*, or concurrently executing subtasks, although it can be interrupted by the timer or hardware interrupts. Therefore, the strategy routine must protect itself against its own interrupt components by disabling the interrupts when it checks resources, such as status ports or device queues, that are shared with those components.

In addition to interruptions from hardware and the timer, the strategy routine also can voluntarily give up control to a thread of equal or higher priority. Whatever the mechanism that suspends the execution of a driver thread, the possibility always exists that OS/2 will issue a subsequent request to this driver before restarting the suspended thread. Therefore, the strategy routine code must be fully reentrant.

The strategy routine must be able to run in both real mode and protected mode. To make this possible, OS/2 ensures that the drivers, the DevHelp services, and the request packets all reside in the lower megabyte of memory, because real mode execution is limited to that area. Furthermore, the addresses of the DevHelps (at initialization) and the request packet (at every entry) are passed along to the driver in bimodal form. To accomplish this task, OS/2 cleverly sets up the kernel's memory descriptor tables so that the segment portion of the address is simultaneously both a physical segment address as well as a selector for a descriptor to that same location.

The strategy routine's calling convention requires that its entry sequence be written in assembly language (because of the pointer passed in ES:BX). However, once inside the strategy routine, a high-level language, such as C, can be called. In this case, the assembly language portion must set up all of the addressability conditions expected by the C routine and normally per-

## TABLE 3: *Operations*

| CODE | TYPE[a] B | C | OPERATION |
|---|---|---|---|
| 00H | ● | ● | Initialize. |
| 01H | ● | | Check media. |
| 02H | ● | | Build BIOS parameter block (BPB). |
| 03H | | | Reserved. |
| 04H | ● | ● | Read from device. |
| 05H | | ● | Peek (nondestructive read, no wait). |
| 06H | | ● | Get input status. |
| 07H | | ● | Flush input buffer. |
| 08H | ● | ● | Write to device. |
| 09H | ● | ● | Write and verify. |
| 0AH | | ● | Get output status. |
| 0BH | | ● | Flush output buffer. |
| 0CH | | | Reserved. |
| 0DH | ● | ● | Open device. |
| 0EH | ● | ● | Close device. |
| 0FH | ● | | Check for removable media. |
| 10H | ● | ● | IOCTL. |
| 11H | ● | | Reset media. |
| 12H | ● | | Get logical drive map. |
| 13H | ● | | Set logical drive map. |
| 14H | | ● | Deinstall (terminate the driver). |
| 15H | | | Reserved. |
| 16H | ● | | Query hard-disk quantity. |
| 17H | ● | | Get hard-disk logical unit map. |
| 18H | | | Reserved. |
| 19H | | | Reserved. |
| 1AH | | | Reserved. |

[a] *B = block device driver*
*C = character device driver*

**To help convert DOS drivers to OS/2, most device-driver operation codes are the same in both systems.**

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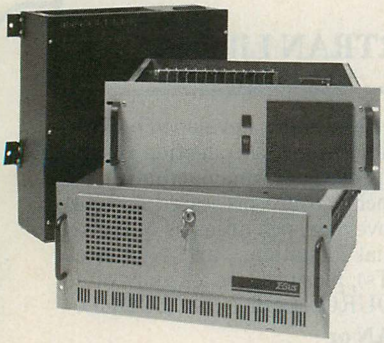




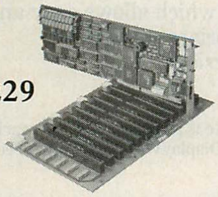
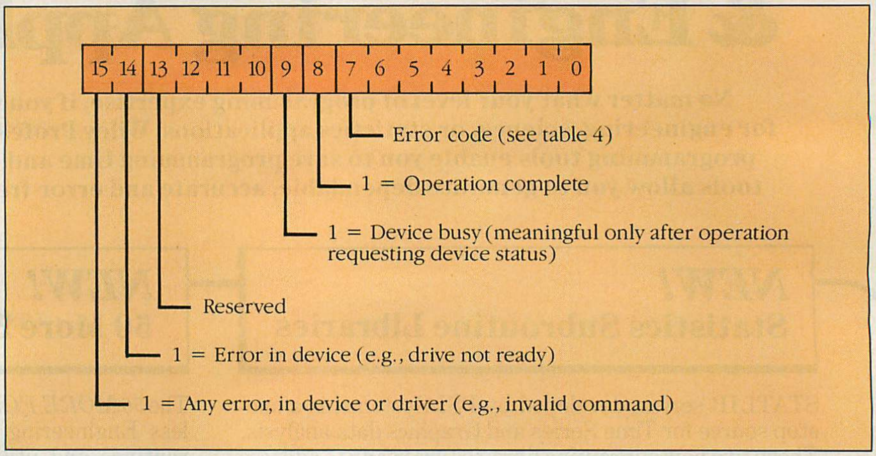




**FIGURE 8:** *Device Status Word*




The device driver uses the status word in the request-packet's header in order to pass information about the I/O operation back to the operating system kernel.

**TABLE 4:** *Error Codes*

| CODE | MEANING |
|---|---|
| 00H | Write protect violation. |
| 01H | Unknown unit. |
| 02H | Device not ready. |
| 03H | Unknown operation. |
| 04H | CRC error. |
| 05H | Bad drive request structure length. |
| 06H | Seek error. |
| 07H | Unknown media. |
| 08H | Sector not found. |
| 09H | Printer out of paper. |
| 0AH | Write fault. |
| 0BH | Read fault. |
| 0CH | General failure. |
| 0DH | Disk change. |
| 0EH | Reserved. |
| 0FH | Reserved. |
| 10H | Uncertain media. |
| 11H | Character I/O interrupted. |
| 12H | Monitors not supported. |
| 13H | Invalid parameter. |

Codes returned in the low-order byte of the status word are meant for the OS/2 kernel, not for the application program requesting the I/O.

formed automatically by a start-up routine supplied with the compiler. An assembly language interface also is required by the register-based DevHelp calling sequence.

### OPERATION SPECIFICS

Most operations performed by an OS/2 driver are similar to those performed by DOS drivers; any differences are described here. For full details, see the OS/2 documentation.

**Initialize (code 00H).** When calling the strategy routine for initialization, the kernel passes the following three pieces of information in the request packet: the address of the device helper services, the address of the arguments from the DEVICE = line, and the next available drive number for the first block-device unit.

The two addresses are bimodal. The strategy routine normally saves the device helper address in its data segment. Then it examines the argument string for user-supplied parameters, and performs whatever initialization is needed for its own internal data structures and for the devices that it controls. Finally, the routine attaches to any BIOS and hardware interrupts that it will be handling.

If all of these operations are successful, the driver sets the "done" bit and resets the error indicators in the status word. For block devices, it also returns the number of units and a pointer to an array of BIOS parameter blocks (BPBs) that specify the logical dimensions of each drive, including the number of tracks and heads, the clusters per sector, the size of the root directory, the size of the file-allocation tables, and so forth. Disks that are formatted with either DOS or OS/2 keep a copy of the BPB in the boot record.

If an initialization failure occurs, the driver should return values of zero for the number of units, code length, and data length, and set appropriate error indications in the status word. Initialization code can reside either in the driver code segment or in one or more additional segments. In either case, when the driver returns at the end of the initialization process, the

kernel shrinks the resident code and data segments to the requested size and deallocates any other segments.

**Partitioned disk support (codes 12H, 13H, 16H, 17H).** OS/2 provides full support for partitioned disks. It permits division of a disk into partitions and assignment of a logical unit number to each partition, in effect treating each as a separate drive. This has become a standard way for DOS to deal with any fixed disk that exceeds the DOS limit of 32MB. OS/2, using the same file system as DOS, resorts to the same tricks.

A disk device driver must provide a BPB for each unit of a partitioned volume, and each partition must have a boot sector containing the information to be placed in the BPB. The driver also must maintain an internal table specifying the relationship among unit numbers, devices, and partitions. Operations 12H and 13H can query or change this table, for adjusting the assignment of logical units to physical partitions. Operation 16H allows for determining how many physical disks are being handled by the driver; and operation 17H gives the complete mapping for the region between the logical units and the partitions.

**Deinstall (code 14H).** Immediately after loading a character driver, OS/2 checks to see if the device name and the attribute field match a previously-loaded driver. If they do, a deinstall request is sent to the driver that was loaded first. If that driver accepts the deinstall request, then the new driver is sent an initialization request; otherwise, the new driver is not initialized. The driver being asked to deinstall must release memory blocks that it allocated via the device helper services, detach from all interrupts, and release any ABIOS resources that it has claimed.

This deinstall request is new with OS/2. In DOS, an installed driver could be replaced without being notified, and as a result the interrupt vectors and device registers could be left in an awkward state. In OS/2, an installed driver can remove itself gracefully. The first driver can also refuse to step aside. And indeed, some computer manufacturers may choose to ship versions of OS/2 with special drivers that cannot be overridden.

**Read/write requests (codes 04H, 08H, 09H).** OS/2 drivers are markedly different from their DOS counterparts in this area because an OS/2 driver strategy routine must contend with two new requirements. First, the driver must be able to cope with potential problems in accessing the user's data buffer during the operation; the addressing mode could change, and the virtual memory manager could move segments between task time and interrupt time. Second, the driver must allow efficient multitasking; it cannot monopolize the CPU while data are being transferred.

OS/2 provides a good deal of assistance in dealing with the first requirement. When the OS/2 kernel sends a read-or-write request packet to the driver, the kernel already will have locked the caller's buffer into memory so that it will not be swapped out during I/O. The kernel also loads the request packet with a physical address that specifies the buffer location independently from the current addressing mode (real or protected); a 24-bit value represents the buffer location in the 16MB physical address space.

For a device that uses DMA to access the user's buffer, the driver simply passes the physical address to the DMA controller. However, if the driver itself reads from or writes to the user's buffer, it must first call the device helper services to translate the physical address into a virtual address. If the driver is operating in real mode, the virtual address is in *segment:offset* form; in protected mode, a *selector: offset* pair is returned. The kernel, not the driver, determines the mode and the target address format.

PhysToVirt, the DevHelp service that performs this translation, also makes the appropriate changes to the local or global descriptor tables to ensure that the buffer is mapped into the driver's memory space. If PhysToVirt is called from real mode with a physical address above 1MB, the driver thread is temporarily switched to protected mode. This does not normally happen with the strategy routine, because it runs in the same mode as the requesting task that sets up the buffer. However, this can occur in the interrupt routines if the CPU is switched from protected mode to real mode between task time and interrupt time.

If the PhysToVirt service is used, then the driver must call its companion service, UnPhysToVirt, before returning to the kernel or yielding control of the CPU in any other way. This service restores the LDT, GDT, and addressing mode to their original states. (Physical address translation also will be covered in more detail in part 2.)

A DOS driver is not designed for multitasking, as DOS does not attempt to share the CPU among several applications. A DOS driver typically initiates a read-or-write operation, then just sits

there in a tight loop waiting for the device to finish. DOS also does not support asynchronous I/O. Because OS/2 supports both these features, OS/2 drivers must relinquish control of the CPU during read-and-write operations. To relinquish control, the strategy routine checks whether the device is busy with another I/O operation. If the device is busy, the strategy routine places the request packet into a device queue via the device helper services. If the device is idle, the strategy routine issues the necessary programmed I/O commands to start the operation. Usually the strategy routine also will start a watchdog timer that will generate an interrupt if the operation does not come to completion within a certain period of time.

In either case, the strategy routine should then return to the kernel, leaving the completion flag (bit 8 of the status word) reset. The kernel then will block the thread until the driver-interrupt routine calls the device helper DevDone. If the strategy routine needs to perform additional work after the data transfer, it can suspend its own execution via the Block function until the interrupt routine reawakens it by invoking the Run function.

When the device generates an interrupt, the driver's interrupt routine checks whether all stages of the current data transfer operation are finished. If they are not finished, the driver initiates the next stage. Otherwise, it signals completion by calling DevDone or Run, as appropriate. Depending on the design of the driver, the interrupt routine may also have to cancel the watchdog timer for the operation just completed. Each time the interrupt routine completes an operation, it checks the device queue for pending requests; if one is found, it initiates the next operation.

If an error occurs during data transfer, the interrupt routine places the appropriate error code in the request packet and sets the error flag before signaling completion. If the watchdog timer interrupt occurs, the timer interrupt routine issues the necessary PIO commands to clear the device. Then it places an appropriate error indication in the request packet and calls DevDone or Run.

This procedure does not seem to support asynchronous I/O, because the thread where the I/O request originated is blocked from task time until interrupt time. Asynchronous I/O is actually supported by the kernel and is transparent to the driver. When the kernel services the API DosReadAsynch or DosWriteAsynch call, it creates a new thread that calls the driver and waits for completion while the application thread continues its execution.

**I/O control (code 10H).** Over time, IOCTL support in DOS has grown in a somewhat disorganized fashion as each version added ever more capabilities to device drivers. In OS/2, the IOCTL feature has been reorganized into one driver command (versus three in DOS) that currently provides more than 100 driver-specific services. OS/2 also has introduced design rules that perhaps will keep IOCTL from getting out of hand once again. (More will be given on these rules in part 2.)

The most important consideration about the IOCTL request is that OS/2 cannot provide the same level of driver support that it does for read-and-write requests. Because the operating system does not know whether a particular IOCTL request requires data transfer, it does not lock any data buffers into physical memory or check the validity of addresses supplied by the calling routine. The device driver itself must take care of these matters.

For a typical driver, most IOCTL requests are just bookkeeping operations and do not require any complicated interaction between the driver and the device. However, if significant amounts of data must be transferred (for example, to read a defective track table from a disk drive), then the IOCTL procedure must follow the same guidelines that reading and writing must observe—the driver must convert buffer addresses to the correct virtual type and must relinquish the CPU during I/O delays. Operation of the other driver functions is similar to DOS functions. (See table 3 for a list of device-driver operations.)

Although device drivers for OS/2 and DOS perform similar functions, three major differences distinguish OS/2 drivers: they must operate interchangeably in either real or protected mode, they must allow efficient multitasking, and, because they cannot use BIOS, they must be programmed down to the hardware level. This makes the OS/2 drivers somewhat more complex than DOS drivers, but mastering them opens the door to a major method for the extension and the enhancement of this new operating system.

*David A. Schmitt is president of Lattice, Inc., developers of the Lattice C Compiler and now a subsidiary of SAS Institute. Mr. Schmitt also developed the Lattice C library and has recently been directing the adaptation of this library to OS/2.*

## LISTING 1: DRIVER1.HDR

```
; ****************************************************************
; Define the data segment and the driver header for 1 device
; ****************************************************************

DATA    SEGMENT WORD PUBLIC 'DATA'

LPT1    DD      -1              ; Linkage
        DW      8880H           ; Device attribute bits...
                                ;   15      => character device
                                ;   11      => open/close support
                                ;   09-07 => driver type 1 (OS/2)
        DW      OFFSET STRATEGY ; Offset to strategy routine
        DW      -1              ; Reserved
        DB      'LPT1    '      ; Device name
        DB      8 DUP(0)        ; Reserved
                                ; End of device header
                                ; Put any other driver data here
DATA    ENDS                    ; End of data segment

; ****************************************************************
; Define the code segment
; ****************************************************************

CODE    SEGMENT WORD PUBLIC 'CODE'
        ASSUME  CS:CODE,DS:DATA

STRATEGY PROC FAR               ; Start of strategy routine
        :
        :
STRATEGY ENDP                   ; End of strategy routine
CODE    ENDS                    ; End of code segment
```

## LISTING 2: DRIVER2.HDR

```
; ****************************************************************
; Define the data segment for 2-device driver
; ****************************************************************

DATA    SEGMENT WORD PUBLIC 'DATA'

LPT1    DW      OFFSET LPT2     ; Linkage
        DW      SEG LPT2
        DW      8880H           ; Device attribute bits
        DW      OFFSET S_LPT1   ; Strategy routine for device 1
        DW      -1              ; Reserved
        DB      'LPT1    '      ; Device name
        DW      4 DUP(0)        ; Reserved

; ****************************************************************
; This is the header for the second device
; ****************************************************************

LPT2    DD      -1              ; Linkage
        DW      8880H           ; Device attribute bits
        DW      OFFSET S_LPT2   ; Strategy routine, device 2
        DW      -1              ; Reserved
        DB      'LPT2    '      ; Device name
        DW      4 DUP(0)        ; Reserved
                                ; End of headers
                                ; Put any other driver data here
DATA    ENDS                    ; End of data segment

; ****************************************************************
; Define the code segment for both devices
; ****************************************************************

CODE    SEGMENT WORD PUBLIC 'CODE'
        ASSUME  CS:CODE,DS:DATA

STRATEGY PROC FAR               ; Start of strategy routine
                                ; Enter here for LPT1,
S_LPT1: MOV     AX,1            ; set LPT1 indicator
        JMP     S_LPT
                                ; Enter here for LPT2,
S_LPT2: MOV     AX,2            ; set LPT2 indicator
                                ; Fall into common
S_LPT:  :                       ; printer strategy routine
        :
STRATEGY ENDP                   ; End of strategy routine
CODE    ENDS                    ; End of code segment
```

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*Systems professionals gather to discuss their sunny future: desktops will dominate, standards will develop, connectivity will work. But, they ask, what do we do in the meantime?*

SUSAN HOLLY

Hurry-up-and-wait emerged as the prevailing theme of *PC Tech Journal*'s first Systems Forum: wait for PS/2s to find their niche; wait for OS/2; wait for a LAN standard; wait for SQL data managers; wait for the famous San Diego sun to come out.

For 2½ cloudy September days in the Southern California city that boasts permanent sunshine, more than 300 participants debated the future of computing from the desktop perspective. Industry experts and systems professionals sat on 10 panels built around the decisions regarding hot topics in the PC world today: hardware (PS/2s, IBM compatibles, Macs, 286, 386 . . . ); operating systems (OS/2, DOS, UNIX . . . ); development (conventional programming, AI . . . ); networks (will a single standard emerge?); and data management (is SQL the key?).

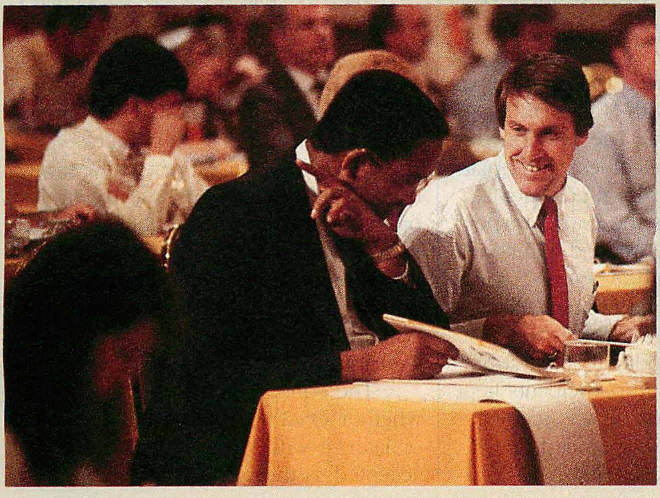
While no one seemed to doubt that the desktop is the future, many expressed frustration over waiting for the future to arrive. "When will we have standards? What do we do in the meantime?" they asked. The answers were not always satisfactory: "You make do, you wait, but it will never be a perfect (read standardized) world."

During the course of the 1987 Systems Forum, participants offered these

PHOTOGRAPHY • JOHN R. STINSON

More than 300 participants converged on the Sheraton Harbor Island in San Diego to help solve a PC mystery: how to use the power of the desktop to accomplish the computing goals of your corporation. After 2½ days of lively debate, Editorial Director Will Fastie announced that discussions could continue at the 1988 Systems Forum, already in the planning stages.


FORUM PERSPECTIVES: Hot topics generate lively debate at the first annual Systems Forum in San Diego. *Clockwise from top left*: Panelists Anthony Schaller, Lynn Geissler, James Eddings, Michael Baker, and Danielle Barr deliver their expert opinions on developing applications in a multiuser/multivendor environment. • *PC Tech Journal*'s Will Fastie presides as master of ceremonies; Editor Julie Anderson looks on from her seat as a panel moderator. • Richard Bader (center) of Intel tells the audience during the PS/2 panel to "buy as much computer as you can afford"; he is surrounded by co-panelists Jill Henness of Wells Fargo Bank and Safi Qureshey of AST. • Alan Ashton (right) of WordPerfect Corporation talks with Dan Delph (left) of American Airlines and an unidentified participant following the "Implications of OS/2" panel. • Forum attendees enjoy themselves. • Esther Dyson, editor and publisher of *Release 1.0*, participates from her front-row seat.

*Top left:* Network designer and implementor Mark Freund (second from right) holds court after declaring during one of the LAN panels that networks should be viewed as "Lego sets, where you can plug them together and redistribute the resources." • *Top right:* Audience members listen attentively for clues to the mystery of how to integrate the desktop into the larger corporate computer world. • *Bottom left:* Keynote speaker Danielle Barr, vice president of corporate automation planning for the Bank of New England, sets the scene by proclaiming the desktop an essential and integral part of the corporate environment.

observations on the current "wait" state that computer professionals find themselves in:

**On waiting for OS/2.** "While everybody waits for OS/2 applications, somebody is going to make lots of money making real solutions to real problems."—Doug Michels, vice-president of The Santa Cruz Operation (SCO).

**On waiting for a LAN standard.** "We have people who need to be connected now. We can't wait for OSI [Open Systems Interconnection]. We need to grab on to whatever tools we have today."—Jeffrey Schwartz, founder and president of InterConnect Data Systems.

**On waiting for SQL.** "We are all waiting for the standards to solidify sufficiently . . . SQL will be a terrific boon to dealing with the distribution of data among different systems on different hardware, but everyone implements SQL in a slightly different way; it's not going to be an ideal world like it is in buying stereos, where you can buy speakers one place and your amplifier somewhere else and just plug them all together and know it's going to work."—Christopher Turnbull, president of Zanthe Information, Inc.

What most everyone did agree on was that the development of standards is paramount in this era of computing in which a variety of desktops running under a variety of operating systems connect to a variety of other micros, minis, and mainframes using a variety of different network protocols in order to use an even wider variety of applications, which somehow must run on all these machines under all these circumstances. Connectivity is unavoidable.

"The age of stand-alone, self-managed computing is rapidly fading," said Danielle Barr in her keynote address at the Systems Forum. Barr knows as well as anyone the complicated environments staring at systems integrators today. As vice president of corporate automation planning for the large, geographically dispersed Bank of New England, she faced the problem of tying together PCs with Wang, DEC, and IBM host systems. The solution was to use DOS-based machines as the platform connected with local area networks (LANs). Across the entire corporation there are 25 LANs and 450 connected PC nodes, with everyone having access to the host via a Systems Network Architecture (SNA) gateway.

The challenge today is integration, according to Barr. But, participants kept asking, what standards do we need in order to integrate? Do we need OS/2? When will all the pieces fit?

"Sooner than a lot of people think," according to Microsoft's OS/2 product manager, Mark Mackaman. The hardware exists, OS/2 Standard Edition version 1.0 will be delivered the first quarter of 1988, and shipping dates for 1.1, which includes the Presentation Manager, will be announced by the end of this year, he said during the "Implications of OS/2" panel. "OS/2 will dominate by the late 1980s."

These answers from Microsoft did not allay many fears, however. "The fog is certainly out there, and it's pretty thick," complained Christopher Broome, senior technical consultant from Arco Petroleum Products. He pointed out the "disappointing" 3½-year discrepancy between the introduction of the AT and the availability of an operating system that can take full advantage of its architecture.

Many people disputed Mackaman's claim that OS/2 would reach a dominant position before the end of this decade. Thomas O'Leary, director of MIS technology for North American Phillips, asserted that both Microsoft and IBM had underestimated the time users would need to migrate from one operating system to the other; it could take as much as a year, he said. Panelist Broome also doubted OS/2 could be dominant by late 1980s. "We have to be prepared to continue DOS support well into the 1990s," he remarked.

The consensus was, however, that whether OS/2 acceptance comes sooner or later, it will come. "OS/2 will be accepted as the principal operating sys-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tem in the business world, if roll-out goes smoothly," Broome said.

The key, everyone agrees, is application development, as Microsoft has clearly acknowledged from the beginning. In Mackaman's words, "The driving force to OS/2 will be new applications. That's when you make the transition to OS/2, not before."

WordPerfect President Alan Ashton echoed that the move should be made "*when there* exist applications that don't exist today—and the users desire them. My advice to users is to wait; my advice to developers is to develop for OS/2." WordPerfect Corporation will move quickly to get a version of its word processor up and running under OS/2, Ashton added.

Compaq's vice president of systems engineering, Gary Stimac, called OS/2 an operating system for the developer. "I think a good software developer will be able to come through. Then we will see if it's worth it."

Mackaman was quick to emphasize that the warning to wait for applications was for end users only. Developers have a "green light to go with it," he said, hopefully.

The ultimate success of OS/2 will not mean the immediate death of DOS. According to Mackaman, Microsoft will continue to update DOS as needed, although "there won't be a dramatic increase in features because application developers have told us, 'don't grow the size of DOS.'"

**Dennis Quinn of the Phoenix Group Incorporated, Farmington Hills, Michigan, tells the Mac panel that his telemarketing group went with PC clones because of the wide choice of software. "What is Apple doing to make more things available?" he asked.**

For many users, DOS is still quite adequate. Ernst and Whinney, a Big 8 accounting firm represented on the OS/2 panel by senior manager Alex Kask, has 6,000 computers, two-thirds of which are portable and three-fourths of which are 8088-based. "Our concern is getting the best out of the machines we already have," Kask said. Most of Ernst and Whinney's users are satisfied with their "old Compaq machines," he explained, so if OS/2 does not increase speed or efficiency, then "we are looking at the emperor's new clothes."

If OS/2 is still several months in the making, what are developers to do in the meantime? What are the alternatives? One suggestion was proffered by Gregory White, systems analyst for Boeing Petroleum Services, when he jokingly (or maybe not) asked Borland representative Daniel Kernan, "Borland always comes up with good, cheap answers; will we see Turbo OS/2?"

Barring that possibility, other popular solutions voiced during the "Alternative Operating Systems" panel consisted of sticking with DOS—as Rod Roark of The Software Link pointed out, Microsoft is hedging its bets by "jumping up and saying 'DOS is not dead'"—or turning to UNIX.

UNIX as an alternative operating system uncovered strong opinions on both sides of the fence. "If an application does not require more than 640K and multitasking, I recommend DOS;

otherwise, UNIX," said Charles Hickey, president of Microport Systems, a developer of UNIX systems. The advent of the 386 and high-resolution graphics will make PCs running UNIX a popular platform for CAD/CAM, according to SCO's Doug Michels. "UNIX is wide open." OS/2, on the other hand, is not multiuser, is not portable across a wide variety of machines, is not widely available in source code, and does not take advantage of the 386, Michels said. UNIX does all this, he pointed out.

Esther Dyson, publisher and editor of the industry newsletter *Release 1.0*, cast the dissenting vote. "UNIX's time has come and mostly gone. People don't like IBM and Microsoft, but they like the idea of a single standard." She explained that many developers will not consider UNIX, opting instead to standardize blindly on OS/2. "That's reality," Dyson said.

**PEACEFUL COEXISTENCE**

Another reality is the IBM hardware standard. Will PS/2s carry on that standard? The Systems Forum jury was still out on this question, but indicated that PS/2s probably would coexist peaceably with other desktops. Jill Henness, manager of workstation support at Wells Fargo Bank, said PS/2 Models 50, 60, and 80 will find a place at Wells Fargo, "but are not the only show in town."

For James Nestor of Ernst and Whinney, the business reaction to the PS/2 is what counts: "Is it compatible? What about those crazy little diskettes? Do I have to learn DOS 3.3? Wait for OS/2? The Software Development Kit costs *how* much? What will PS/2s buy us (performance, graphics, status, and possibly a future), and what will it cost us (hardware, software, media, training, and tech support)?"

The true significance of the PS/2 will not be felt until the other vendors shoot the return volley—in the form of PS/2 clones or upward compatibility, said Richard Bader of Intel's Personal Computer Enhancement Operation. One of those other vendors, Compaq, is looking very closely at the PS/2s, Stimac said, and "if that's what people absolutely want and demand, then we will make the appropriate business decisions to satisfy that segment of the marketplace. I do not believe that there's anything in [the PS/2] that the industry cannot respond to, legally as well as technology-wise."

Of all the PS/2 innovations, the Micro Channel bus has generated the most discussion in the computer industry, as was the case at the Systems Forum. Compaq's Stimac was predictably unimpressed by the new architecture, saying that the Micro Channel bus has no major advantage over the "classic" bus. Bader said he was not convinced that "anything that can be done on the Micro Channel cannot be done on the current technology."

When panel moderator Will Fastie asked how many believe *in the Micro* Channel and how many in the classic bus, the Systems Forum audience appeared to favor the classic version slightly. Many were undecided. Perhaps more telling, however, was his next question, "How many of you find the PS/2 compelling?" No hands went up.

**BLUE APPLES**

Of course, there is always the Apple alternative, which merited its very own panel at the Systems Forum. A substantial number of participants said they already used Macintoshes or were considering buying them. J. B. Leep of Businessland recounted statistics that in a six-month period showed the Mac jumping from 2 to 10 percent of sales at Businessland; that figure is now getting close to 15 percent and some months reaches 20 percent, he said. "This is not a flash in the pan."

Apple's group product manager for the Macintosh, Charles Oppenheimer, dared to explain to the IBM loyalists in the audience why the Mac is being accepted on more corporate desks: enhanced speed and performance, a better multitasking operating system (Finder), the introduction of HyperCard to organize large volumes of data, the ability to share data with PCs, and an effective networking strategy.

The quality and availability of software for the Apple machines have aided their growing acceptance by the business community, according to members of the Macintosh panel. In most areas, people generally agree that the quality of software for the Mac is high. As an example, Leep said he could not think of anyone in his company who had tried Microsoft's Excel spreadsheet for the Mac and then returned to the dominant PC spreadsheet, Lotus 1-2-3. However, Jack Baumann of Hughes Aircraft countered that by saying when people in his company want a spreadsheet, they ask for 1-2-3 because they have heard about it. "They haven't heard about Excel," he said.

Leep pointed out that the only software areas where the Mac is lacking are communications and data management. "Of course, those are pretty big areas," he acknowledged.

Three of the Macintosh panelists freely admitted to having Macs on their desks alongside their IBM or compatible machines. Peter Coffee, engineering specialist for the Aerospace Corporation, has a Mac and an AT "and couldn't live without either one." His company has gone from no Apples to having several pockets of Macs—about 5 percent of the total PC base—used for graphics, programming, and communications. Hughes Aircraft's computer base is two-thirds PCs and one-third Macs, according to Baumann. "Engineers really take to Apples," he said. Another two-computer desk belongs to Dave Winer, founder and president of Living Videotext and owner of a Compaq Deskpro 386 and a Mac II. "They are very compatible in power and memory, but the Compaq has all the slots filled and the Mac has five empty. The infinity of the machine is what is most impressive about it."

The three men concluded, however, that the Macs were doomed to an underling position in each of their companies because of the existing PC user base and because of reluctance from the executive offices. "Because our customers buy AT-class machines in volume, the Mac will never be our dominant machine," Coffee said. Baumann pointed out that many executives hesitate to buy a Mac because "Apple still has the image of a toy."

Or, as Daryl Plummer from the Florida governor's office put it more succinctly, "Real men don't use icons."

### THE AI ALTERNATIVE

Plummer's statement rang true in a later panel discussion of traditional versus artificial-intelligence development environments. Asked how many of the audience had programmed in another icon-oriented environment, Microsoft Windows, less than a handful said yes. "That's a little disappointing," said Rob Dickerson of Microsoft, who sees Windows (and by implication, Presentation Manager) as the beginning of a revolution in development environments. Further, while he expects no big changes in traditional tools, such as compilers, he does believe new categories of tools will become available, including prototypers and program databases. The traditional development environment is continually improving, he said.

But Eugene Wang fired back, "If classic programming were effective, OS/2 would have been delivered by now." Wang is vice president of marketing for Gold Hill Computers an AI development tool specialist.

Artificial intelligence is available and effective on PCs right now, Wang argued. However, AI will not succeed as a stand-alone technology; it must be integrated into the traditional environment, he declared.

AI should be thought of not as a competitor to conventional programming, but as just another set of tools to choose from, panelists agreed. People should not be afraid of it, nor should they consider it magic. They should just use it to solve the correct problem. As Peter Gabel of Arity Corporation put it, "This panel is about using the appropriate technology for different problems." He gave the example of an accounting system, which because of its structured nature can be handled quite nicely by conventional programming. However, if you want to get into the *interpretation* of a balance sheet, he said, "that's exactly where AI technology starts to kick in to help."

Aerospace Corporation's Coffee called AI "not so much a language or product as a perspective." At Aerospace, AI gave the staff a new perspective for looking at a problem, Coffee explained. "The problem is that people don't know what they know." AI brought together the people who had to solve the problem with the people who had the problem, making them far more involved and committed to the process, he said.

### NETWORK FIREWORKS

As is usually the case at gatherings of computer people today, networking is among the hottest of the hot topics and, therefore, stimulates the most heated debates. The Systems Forum was no exception as two networking heavyweights sparred over the development of a single standard during the panel on "Linking Unlike Machines."

Novell's Craig Burton gave little credence to the notion of a standardized network. That the many types and varieties of computers will converge "is about as likely as everyone deciding they are going to drive the same type of vehicle to work," he said. Likewise, he continued, the many network protocols already devised by different vendors are not likely to join up. "Connectivity standardization is so far in the future, I doubt we will see it," Burton concluded.

But users don't want all of these protocols, 3Com's Robert Metcalfe retorted. "They want vendors to clean up their act." The future, according to Metcalfe, will be the Open Systems Interconnection (OSI) standard backed by

the International Standards Organization (ISO), "although it may be two or three years down the road."

Users want solid proof, however. "What evidence do we have that vendor support of ISO is more than lip service?" asked Brent Ostlund, systems design engineer for the U.S. Air Force. "If only some companies support it, that's not good enough."

Digital Equipment Corporation supports the ISO standard, said DEC's Bill Stowe. So does 3Com, replied Metcalfe, and then added, "What else are you going to bet on?"

Until (or unless) that standard becomes reality, users must select the network protocol that best suits their needs. To make such a judgment, they must somehow measure performance, the topic of another Systems Forum panel, "Optimizing LAN Performance."

Performance is subjective, said Rick Watkins of the consulting firm, Micro Development. "How fast is fast? If nobody complains, it's fast enough."

While he supports the underlying assumption that connectivity is good, Watkins warned against expecting too much. Networks do not necessarily result in increased productivity, he said. LANs don't make life better; they make life more complicated."

The direction the LAN should follow today is "to be woven into the corporate fabric," said Mark Freund of InterConnect Network Consulting Group. It should no longer be "a little piece of hardware tied to the mainframe." Instead, the mainframe should be seen as another resource on the network.

**SQL, WHEREFORE ART THOU?**

Compounding the network problem is the distributed database problem, which just about everyone seems to want, but no one has yet mastered. The problem, once again, is waiting for a standard to develop. Until a common database language such as Structured Query Language (SQL) gains widespread acceptance, Systems Forum panelists agreed, data distribution over different types of machines will be fraught with problems.

Robert Byers of Ratliff Software Production and Richard Schwartz of Ansa Software both said they are pursuing SQL as the de facto standard. Dave Browning of WBS and Associates called SQL "a worthwhile effort" that still has lots of faults, but that will improve. Watkins of Micro Development was more hesitant. "Standards are often political. That's why we shouldn't push SQL too quickly."

"The main significance of SQL is not that it's necessarily a common language, but as long as enough vendors of database management systems provide certain common functionality via the SQL language, it is not unreasonable to build general-purpose connectivity software that permits an application running on a PC or workstation to communicate with these heterogenous SQL systems," explained Umang Gupta, whose company, Gupta Technologies, develops distributed SQL software for PCs, minis, and mainframes.

At this point, however, SQL-based applications are not able to handle a production database on a PC, according to some of the panelists. "I don't see anything out there," said Jon F. Nackerud, vice president of technology for Cullinet Software. "The machinery exists and some of the software exists, but they don't exist together." Robert Epstein, cofounder of Sybase, echoed this thought, "If you want to control a nuclear powerplant on a Compaq 386, the hardware is here." What's missing is the software, he said.

"The message we seem to be getting," as one audience member put it, "is if you want to build a production database, you need to do it on a mainframe." For control and security rea-

sons, this may be the case right now, panelists said. Putting a production database on a PC network is the same as "every user having a power switch to the mainframe conveniently located on the desktop," Epstein said. "Control has to be incorporated into the database." Turnbull added that with a database on the mainframe, "you don't worry about somebody coming in and walking away with data under their arm, as you do on micros."

The answer may be that mainframes and minicomputers will host the primary data, while desktops will provide user-interface views of that data, offered Roy Folk, executive vice president of Ashton-Tate. He said that big companies are not going to give up the security afforded by mainframes, and small companies are not going to give up their user interface.

The desktop is important for user interface capabilities, Gupta pointed out, using the example of an airline seat reservation system. Today's dumb terminals don't have graphics or user interface capabilities, which is why airline representatives cannot show you a picture of the layout of an airplane to give you the best seat available, Gupta explained. This brings up an economic issue, Turnbull said. "Are we all willing to pay more airfare to get the seat we want?" Existing applications are not going to disappear, he said. "We are not going to rush out and throw away our mainframes."

"The answer is not always to raise airfares," Dan Delph, senior systems analyst for American Airlines, countered from the audience. He indicated that the movement, indeed, is toward the micro world. "Like many mainframe-centric companies, we are involved in becoming micro-centric. Some of the pieces are there and some aren't."

This view echoed back to the opening speech of the Systems Forum 2½ days earlier when Danielle Barr called the desktop "the platform where we are going to be seeing the developments in computing technology for the future." As revealed through these many hours of discussion at the Systems Forum, this future includes bigger, better operating systems, improved development environments, enhanced connectivity with minicomputers and mainframes, and the promise of the distributed database.

Carrying that message with them, 300-plus participants left the Systems Forum, still waiting for this promising future; but at least the San Diego sun had finally come out.

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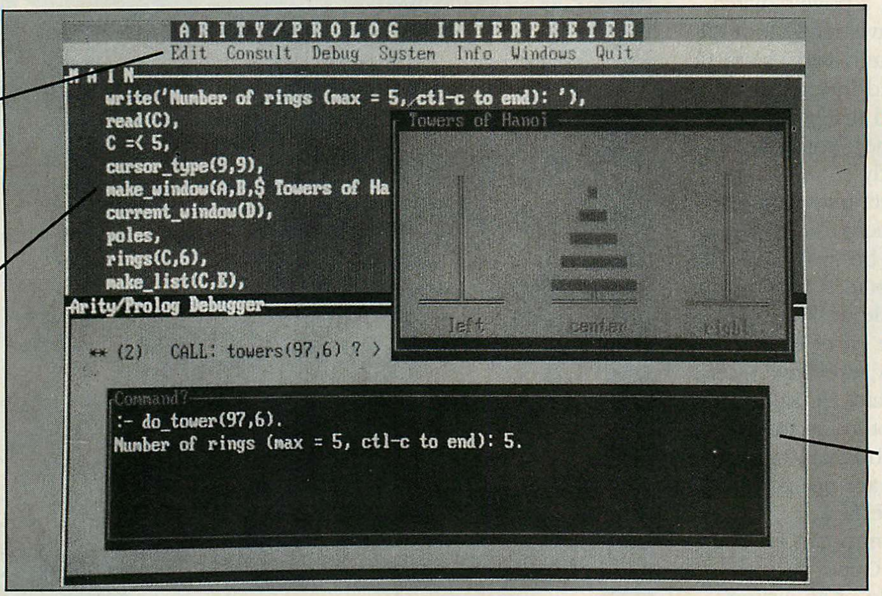


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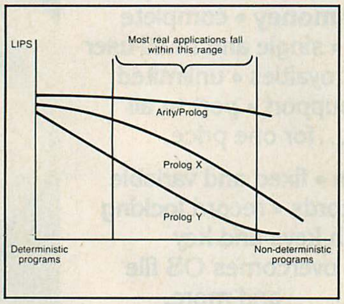


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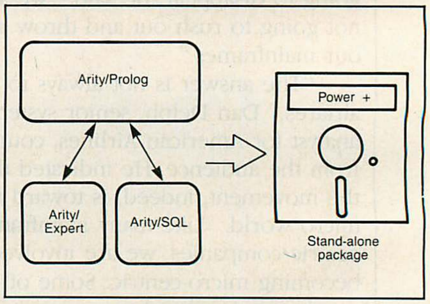


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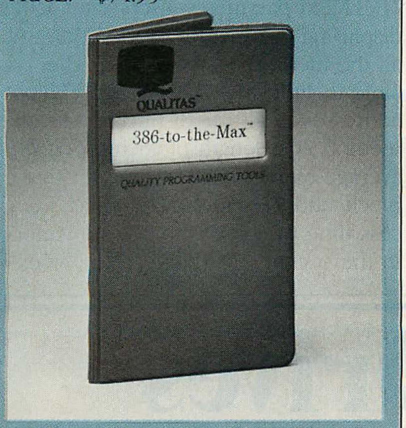



CIRCLE 346 ON READER SERVICE CARD

The 80386 microprocessor has many tricks up its sleeve that earlier Intel processors such as the 8088 and 80286 do not offer. Extra features include a new mode called virtual 8086 mode (for running multiple simultaneous real mode applications), paging (for defining virtual memory systems and for reassigning memory addresses anywhere in the address space), and switching in and out of real mode at will. Several programs are now available for 80386-based computers that take advantage of these advanced processor features to provide handy utilities for DOS users.

One category of 80386 program is the expanded memory manager, such as CEMM provided with the Compaq Deskpro 386, IEMM provided with the Intel InBoard 386, QEMM available separately from Quarterdeck, and 386-to-the-Max from Qualitas, reviewed here. This type of program uses the 80386 paging facility to emulate the Lotus-Intel-Microsoft (LIM) expanded memory specification. With any of these programs, users do not need to purchase special hardware (such as an Intel Above Board) to use expanded memory. Instead, the programs use the paging facility of the 80386 to transform the extended memory (memory whose addresses are beyond 1MB) into the expanded memory.

386-to-the-Max supports version 4.0 of the expanded memory specification, providing all the new features of that specification, such as support for 32MB of expanded memory and features to make it easier for programs to execute out of expanded memory. The program is one of the first 80386 expanded memory managers that currently supports version 4.0 of the expanded memory specification.

If expanded memory was all that 386-to-the-Max provided, it would be a handy program for users of 80386-based computers, but it would hardly stand out among its big-name competitors. But the 386-to-the-Max program includes several other ingenious functions that make it outstanding and perhaps the handiest 80386 memory manager on the market.

One extra feature that 386-to-the-Max provides is filling in unused memory addresses in the first megabyte and making that memory available to DOS applications. There are three kinds of memory filling that can occur.

First, in a system that does not contain a full complement of conventional memory, 386-to-the-Max transforms extended memory into conventional memory and fills in the addresses up to the 640KB limit. This feature is ideal for systems such as those that use the Intel 386AT system board, which contains only 512KB of 32-bit memory but also supports 32-bit extended memory cards. Instead of requiring users to add a slower, 16-bit memory card to fill up conventional memory, 386-to-the-Max can use the 32-bit memory on the extended memory card to supply the remaining 128KB of conventional memory.

This type of memory filling also is available with most other 80386 memory managers, but 386-to-the-Max takes memory filling two steps farther. It fills in any unused memory addresses below the video RAM (which the documentation calls low memory) and makes that memory available to DOS. Then it fills in unused memory addresses above the video RAM (called high memory) and then makes that memory available for the loading of the memory-resident programs.

The amount of low memory that 386-to-the-Max can fill depends on the kind of video adapter in the system. Systems with IBM Enhanced Graphics Adapters (EGAs) that have a full 256KB on board will not gain any low memory, because the EGA memory uses the addresses starting at 640KB. However, systems with monochrome adapters can gain 64KB of additional memory, and those with color/graphics adapters can gain 96KB. This memory is directly available to DOS for running programs. For example, in a system that has a monochrome adapter, invoking a CHKDSK command will reveal that 704KB of memory are available.

386-to-the-Max also fills in any unused memory above the video RAM. This high memory can be used by DOS applications when allocating additional memory and used to load memory-resident programs. Allocating high memory to DOS applications is automatic; the memory is assigned when the application uses DOS function requests. Loading memory-resident programs into high memory requires an extra command. Before invoking a memory-resident program, the user must invoke the program 386MAX.COM with the LOADHIGH parameter. This keys 386-to-the-Max to start loading programs

into high memory. When ready to load programs into low memory again, the user once more invokes 386MAX.COM, this time with the LOADLOW parameter. Because most memory-resident programs are invoked in the AUTOEXEC.BAT file, it is a simple matter to edit that file and insert the appropriate calls to 386MAX.COM.

The amount of high memory available depends on options installed in the computer. A system with an EGA will gain 176KB of real-mode memory (112KB if expanded memory is used). Because this memory is still in the first megabyte, the real-mode memory resident programs can run, but they do not consume precious memory in the 640KB conventional memory range.

386-to-the-Max also provides remapping ROMs to faster RAM. This is ideal for systems that have fast, 32-bit RAM but whose EGA or BIOS ROMs are 8 or 16 bits wide. By copying the ROMs into RAM, the overall system performance can improve.

Also, tying in with the program's philosophy of conserving conventional memory, 386-to-the-Max itself takes up less than 2KB of conventional memory. Other memory managers can take up as much as 64KB. That does not imply that the 386-to-the-Max program is smaller than other memory managers; however, it places fewer than 2KB of itself in the conventional range, placing the remainder in other memory.

The latest version of 386-to-the-Max (version 1.91) provides several additional features that can improve system performance. Hardware interrupts, such as the timer and background communications, are allowed during all EMS function calls as well as during extended-memory-block moves, such as those done by VDISK.SYS. Another important performance feature lets users swap the memory starting address 0 with memory above 1MB. Although its effect on performance is not obvious, it works wonders on systems that contain 80386 accelerator cards such as the Intel Inboard 386. On these systems, memory on the system board is usually slower, 16-bit memory, while the faster, 32-bit memory resides on the accelerator card. Unfortunately, the 16-bit memory takes up the low addresses where often-used code such as DOS resides, while the 32-bit memory is relegated to higher addresses. 386-to-the-Max improves performance on these systems by mapping the system board memory to the high end of extended memory and filling in the first 640KB with 32-bit memory that formerly started at 1MB.

Memory swapping provides two benefits. Not only does it put faster memory where it is used most often, but it also lets accelerator-card users make use of all their memory. Without 386-to-the-Max, many users disable as much of their system-board memory as possible (usually everything but the first 256KB) and use 32-bit memory on the accelerator card for the rest of conventional memory. With 386-to-the-Max, all system-board memory can remain enabled, and 386-to-the-Max will map it up to the high end of memory where it can be used if needed.

The program also provides utility features to help set up the memory mapping in the most effective manner.

By invoking 386MAX.COM with the TIMEMEM parameter, users see a table displaying the memory access times of all the memory in the system. The table includes the starting and ending addresses of all the distinct blocks of memory, the length of each block, the average memory access time for that block, and the ratio of that block's access time to that of the fastest memory in the system. This table can show ex-

actly where fast and slow memory are located in the system.

For additional help, 386MAX.COM can be invoked with the MAPMEM parameter to show for what the memory currently is being used. This option lists the names of the currently loaded programs, their starting addresses, ending addresses, and lengths. The information can show how the different types of memory are being used. It also can help users determine the order in which memory-resident programs should be invoked to get optimum use from high memory.

Finally, 386MAX.COM can be invoked with the ROMSCAN option to list the addresses and length of the ROM in the system. Users can compare this display with the TIMEMEM display to make a determination of how fast the ROM in their systems is.

386-to-the-Max operates as a device driver, so installing the program involves placing a DEVICE = 386MAX.SYS command in the CONFIG.SYS file. There are several options to control the amount of extended and expanded memory, the expanded memory page frame address, the type of memory filling that should occur, and which ROM addresses should be remapped. But, except for the expanded and extended memory sizes, these options mainly are for those special circumstances when users wish to turn off one or more of the features. For most users, the default command sets up the program perfectly, finding and filling unused memory addresses, remapping ROM appropriately, and assigning the remaining extended memory to the expanded memory without requiring the user to make any calculations.

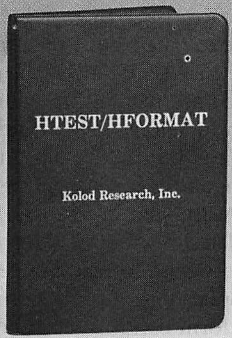
At the time of this article, Qualitas was shipping version 1.91 of 386-to-the-Max. This version contains all the features mentioned in this article, but the documentation consists of an earlier manual augmented with a README file. When the final manual is complete, Qualitas plans to update all registered customers with the up-to-date manual and the latest version of the software free of all charges.

386-to-the-Max is a handy expanded memory manager for 80386 systems, with enough extra features to make it a cut above similar programs offered by better-known competitors. Its reasonable price, good performance, and simple installation make it an extremely compelling program for any owner of an 80386-based PC.

—STEVEN ARMBRUST

**HTEST/HFORMAT**
*Kolod Research, Inc.*
*P.O. Box 68*
*Glenview, IL 60025*
*312/291-1586*

PRICE: $89.95




**CIRCLE 345 ON READER SERVICE CARD**

The collection of hard-disk utility programs that make up HTEST/HFORMAT is designed to provide a set of tools that (when they are used in conjunction with the DOS programs FDISK and FORMAT) help set up, optimize, and maintain hard disks and facilitate recovery from some kinds of disk malfunction. However, thus far, the programs have been greeted only with partial success.

HTEST, the disk testing program, performs either destructive (write/read) or nondestructive (read-only) testing. A variety of test parameters can be specified by the user, including the pattern of head movement during the test, the number of test loops that were performed, and the region of the disk that was tested. If an individual sector does not pass the test, its sector number is returned along with an error code.

Testing, which was carried out using earlier versions of this program, was time consuming; it took 45 minutes to perform the fastest of the available testing routines on a 20MB disk. However, the version that is reviewed here (version 1.7) runs much faster because the routines now by default test tracks three times instead of thirty-two times as done before.

HOPTIMUM is a unique feature of this package. This program determines the optimum interleave factor for the hard-disk/ system combination. HOPTIMUM formats a small section of the disk at each of several interleave factors—the default range is 1 through 16, but the user can change it—then determines the time needed to read data from that section. The test can be performed on as small an area as one disk cylinder (a typical 20MB disk has 611 cylinders); the location of this cylinder also can be specified to fall onto an empty area of the disk.

The test takes a long time, almost 10 minutes per interleave value tested; however, the results are quite instructive. HOPTIMUM was run on a Seagate ST225 20MB disk running in a "turbo" IBM PC/XT clone (8-MHz clock speed), and the results indicated that an interleave of 4 is best for the system tested. Unfortunately, the disk formatted with the dealer-recommended interleave of 3 was used, the slowest value! Reformatting the disk with an interleave of 4 dramatically sped up disk reads. The load times for large programs, such as Microsoft's WordPerfect and Lotus 1-2-3, indicated that there was a decrease of almost 50 percent.

HFORMAT performs low-level formatting and testing of hard disks. Various formatting parameters can be specified, such as the interleave factor, the number of formatting attempts, and the beginning and ending cylinder and head numbers (to format selectively only a portion of the drive). In addition, the maximum cylinder, head, and sector numbers can be specified, which theoretically would permit formatting and testing of disks not covered by BIOS parameters. However, to use a disk whose parameters are not covered by BIOS, the disk must be autoconfigured. Since the HFORMAT program does not support autoconfiguration, the flexibility available in specifying formatting parameters is of limited use.

This HTEST/HFORMAT package includes both GETSEC, which reads from user-specified sections of the disk and puts the data into a DOS file, and PUTSEC, which performs the operation in reverse. A head-parking program is included in the package as well.

Programs that take parameters can be run in either command line or menu mode. In menu mode, the user interface is poorly implemented. For example, in order to change only one parameter, the user must scroll through the entire parameter list.

The documentation is contained in a small booklet and in a five-page READ.ME file on the distribution disk. Quality is spotty—some things are explained well and some not at all. Given the complexity of hard disks and the dangers inherent in formatting and in destructive testing, a clearer and more complete manual is sorely needed.

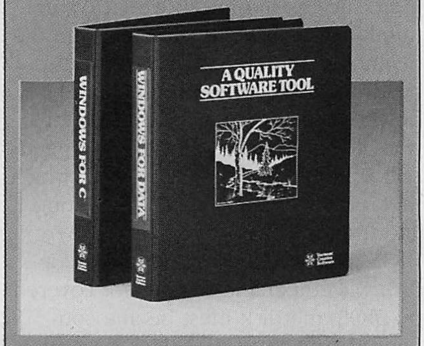
HOPTIMUM certainly shines as the outstanding program of this package. This program has the ability to determine quickly the optimum disk interleave, which can save hours of reformatting and testing time. The other routines are sufficiently useful to make this package an attractive one both for the user who desires to test the performance of a particular system as well as for the integrator who is interested in matching the performance of various disks to various systems.

—PETER AITKEN

**Windows for Data**
**Windows for C**

*Vermont Creative Software*
*21 Elm Avenue*
*Richford, VT 05476*
*802/848-7731*

Windows for Data, object code, $295; source code, $295
Windows for C, object code, $195; source code, $195




**CIRCLE 347 ON READER SERVICE CARD**

Windows for Data (WFD) and Windows for C (WFC) from Vermont Creative Software (VCS) are two products designed for programmers developing applications in C. WFD is a system designed to support the design, generation, and management of data-entry forms within screen windows. WFC enables the programmer to create window-based interface screens by incorporating an integrated set of functions.

**Windows for Data.** WFD is a forms-oriented data-entry package built on top of WFC. WFD includes the complete WFC package. Therefore, an application using WFD can access all the capabilities of WFC.

WFD models the process of filling out a paper form. The application creates a window and displays an image of the form. The form may be larger than the window and can be scrolled horizontally and vertically. Certain areas on the form are reserved for data entry. These fields are highlighted one at a time, and the operator enters the appropriate data. At the end of the form, the data are delivered.

The application builds a form by calling WFD functions to specify text, reference a window, and define fields. Field characteristics such as location, prompt text, data format picture, and field type may be defined. The fields to be entered are marked by calling field definition functions. As each field is entered, it is validated against a field definition, and incorrect entries are flagged. At the end of form, all fields are translated from display format to internal program format and returned to the application.

The form controls attributes for the fields, sets the rules for field motion, and has a help text available. Most of the data-entry modes can be set separately for each form.

The data-entry window may be any type of window supported by WFC, including pop-up and memory file. Once that a form is created, other functions are employed in order to add text or to create data-entry fields.

Fields may contain any standard C language data type (string, integer, character, long integer, float) plus Boolean yes/no, time, date, decimal, and menu. Fields also may be designated as protected (no data entry), required (must be entered), and invisible (for passwords) and be given a picture. Pictures can limit data entry to only certain characters, such as numeric, or provide protected characters within a field. For example, the picture for a telephone number might be "(999) 999-9999." When this field is displayed, the () and – characters will be displayed on the screen but will not be passed to the application.

WFD automatically provides a system validation function that verifies that the input to each field is correct for the field type and picture. In addition, the application may have a validation function for each field. For example, this function can validate data with a range check or a table lookup. These functions can use WFC's pop-up windows to display error messages.

Fields may have a subform or a menu attached to them so that, when the operator enters the field, the form or menu will appear. This is handy for the operator who wishes to make menus for multiple-choice fields.

One other particularly useful feature for writing commercial applications is the scrollable subform. This is a simple way to do the classic invoice form, which has a fixed section at the top and bottom and a list of items in the middle, with the same format for each line in the list. The list can be written as a scrollable subform longer than the section of screen containing it.

WFD also extends the WFC help system. Both forms and fields can have help messages attached. One key is defined to display field help when it is first pressed and form help on the second. The help text may be either compiled into the program or may be contained in a memory file.

A form-design utility is packaged with WFD that helps produce the C code for forms (see figure 1). The application programmer prepares a form-definition file that contains the form text and field definitions as well as additional commands to specify other WFD options, if needed. The form-definition file is a standard ASCII file and can be prepared with almost any text editor. (WFD, however, does not include an editor.) The form-design utility acts as a compiler, reading the definition file and generating sections of C code to build the forms. These code fragments are then incorporated into the application.

The code **rowq** in figure 1 sets the number of rows in the form, **colq** sets the column width. LNORMAL is the logical attribute for normal text. The field delimiters (carat, less than, and percent sign) both mark the fields and determine the field type. The string between them is the picture for the field.

The problem with the approach taken by WFD forms designer is that delimiters used to specify field location and characteristics are not included in either the field length or the text. This makes it difficult to get everything placed accurately on the form, because the delimiters throw off the vertical alignment of fields, and their true location is not shown.

This utility is the one real disappointment in an otherwise excellent package. Other form-handling packages provide interactive editors that allow for creation of a form by working with an exact screen image, complete with all attributes, borders, lines, text, and fields in their proper position. The design utility is hardly easy to use, flexible, or friendly. It is representative of the state of the PC screen- and form-design programs of several years ago, and it is easily outclassed by most modern design packages.

**Windows for C.** WFC is a basic windowing system for C programs. It provides a set of functions to create and destroy windows, set their screen location, control their contents and perform many other operations automatically, all completely under control of the application. This is quite different from windowing in Microsoft Windows or IBM's TopView, where these are nearly operating systems in their own right and control the application as much as they are controlled by it.

To use WFC, the programmer builds a data structure describing a window and calls a function to open the window. This function can automatically save the previous contents of the screen area, clear the area to the proper colors, draw the window border and label it. Once the window is open, it can be treated much like a standard I/O device. WFC provides procedures to write text to the window, change colors, set the cursor position, and perform almost all operations that could be done to the screen itself. When the window is closed, WFC removes it and restores the previous contents of the area if desired. The usual "introductory" C program written for WFC is shown in figure 2.

This program initializes the windowing system and defines a window beginning at line 10, column 30 and extending for 8 lines and 25 spaces, with a double-line border. Then, it makes the window visible to the user and writes the string "Hello world."

A WFC window may be pop-up or standard; a pop-up window saves the context of the screen area in which it is created and restores the area when the screen is closed, whereas a standard window, simply overwrites the screen without saving it first.

Each WFC window has a separate cursor that may be controlled by the application and that is automatically updated by writing. Procedures allow writing strings, with or without scrolling, centering, or justification. The application can scroll the window contents as well. One function provides a full equivalent of **printf** within a window. Window contents also may be read by the application.

Window attributes are particularly well handled and may be specified either physically or logically.

Physical attributes are the ones used by the video hardware (the PC video attribute bytes that determine the characteristics of the associated display characters). They provide full control over the available features but are different for different types of display, such as IBM's Professional Graphics Controller (PGC) and Enhanced Graphics Adapter (EGA). When physical attribute control is used, the application must determine what type of hardware is used and react accordingly.

Logical attributes are specified by function, such as normal text, highlighted text, or error messages. When the program is run, WFC determines the display hardware and converts the logical attributes (such as error messages) to physical ones (such as highlighted characters). This lets a program operate unchanged on monochrome, on the IBM Color Graphics Adapter, or on the EGA video cards.

The application can modify the logical to physical attribute mapping, thus customizing WFC to work on a variety of video equipment. Both kinds of attributes, though, are handled by WFC functions as attributes of the window, not of the text, making it impossible to set the attribute on individual words within a window.

Another useful high-level feature in WFC is the memory file, which stores text that can be written or read by the application. WFC can move a memory file to or from disk, and the contents can be displayed by attaching an open window to the memory file, either at a location specified by the application or the window can be moved through the file using the cursor keys. Space for memory files is allocated and deallocated, using the C memory-allocation functions.

Memory files that are wider or longer than the window size may be scrolled horizontally and vertically. VCS provides the source for the scroll func-

**FIGURE 1:** *Form Design*

```
..rem     This is a sample form design file
..rowq 12
..colq 72
..att LNORMAL

                    DATA ENTRY FORM
                    _______________

First Name:     ^!XXXXXXXXXXXXXXXXXXXXXXXX^
Last Name:      ^!XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX^
Company:        ^!XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX^
Date:           <99/99/99<
Invoice #       %9999%
```

Example of code used in form design. The form-design utility acts as a compiler, reading the definition file and generating C code to build the forms.

**FIGURE 2:** ***Introductory C***

```
#include <wfc.h>
#include <wfc_glob.h>

main()
{
  WINDOW wn;

  init_wfc();
  defs_wn (&wn, 10, 30, 8, 25, BDR_DLNP);
  set_wn  (&wn);
  v_st ("Hello, world\n", &wn);
  return (0);
}
```

**The introductory program was written for Windows for C. The program initializes the windowing system and defines a window with a border.**

tion, so the programmer can expand it to suit the application.

Memory files are the basis of WFC's menu system. The application builds an image of the menu in a memory file and opens a window for it. The menu procedure controls motion and selection and returns an index of the selected item. An item may be selected by putting a cursor bar on the item and pressing RETURN or by typing the item's initial letter. Since menus are memory files, they can be larger than the window containing them.

It should be noted that WFC windows into files operate only on files that have been read entirely into memory—disk files cannot be manipulated directly within windows.

Memory files are also used for WFC's very simple help facility. When the user asks for help, WFC opens a memory file, reads the help text into it, opens a pop-up window, and attaches the memory file to the window. Once the window is open, the operator can scroll through the help file. When the operator exits help, closing the window restores the screen contents.

As is appropriate to a complex system, WFC incorporates several debugging aids. The simplest is that the WFC header files include full function prototypes. This allows C compilers, which support function prototyping, to check function calls for correct number and kind of arguments. This will catch most simple errors in C. Each WFC function incorporates its own error checking and returns an error code. In addition, the error code is stored in a global variable used by all functions.

The application also may install a global error handler. This function will be called whenever any WFC function registers an error. It might not indicate the specific source of the error but is active for all functions. The handler could substitute for checking the error code on every WFC function.

Unlike the global error handler, which is always available, two other debugging aids are only enabled on request. Error traceback causes WFC to keep a log of function calls. When an error is registered, WFC will pop up two windows, the first giving a log of function calls up to the point of the error, and the second giving the path of function call from the main program to the point of the error.

Memory-integrity checking is a debugging aid that operates as the application runs. When enabled, critical WFC data structures are verified frequently by using checksum or checking known tags. Verification failure probably means memory was overwritten by an incorrect pointer reference. This tool gives an error traceback for the function that discovered the error and a dump of the region affected.

These tools are enabled only on request because they can cause a significant increase in program size or run time. When these features are not enabled, the debugging system takes almost no overhead.

WFC will work with either TopView or Windows as a "well-behaved" application. When a WFC application starts up, it checks to see if it is running stand-alone or under Windows. Stand-alone applications write directly to video memory for speed, whereas applications running under Windows or TopView will use the interfaces required by these environments. WFC applications may execute within an MS or a TV window, but they will not make use of all the features of those systems; for example, the resizing feature is not supported.

WFC does not support a mouse directly; however, it can work with mouse drivers that generate keyboard characters. The documentation includes examples of how to use WFC with the Microsoft Mouse as well as the PC Mouse.

In addition to the MS-DOS versions, WFC is available for Unix, Xenix, and VAX/VMS. All versions are very similar, and, with a little care, applications can be written so that the same source runs in all environments.

The WFD and WFC package arrives in two 8.5-by-11 loose-leaf binders and four disks with only a minimum of installation instructions.

The package addresses experienced C programmers, and it shows. The documentation is clear but not so detailed. Each binder is about one-third narrative, one-third example code and listings of the provided header files, and one-third function definitions in a format that will be uncomfortably familiar to anyone who has ever seen a Unix manual. This is reference material, not a tutorial. Little basic information is provided, the bias clearly is toward experienced users.

The organization of the manual diminishes its readability. All the examples and tables are grouped in one section rather than located with their associated text; thus the reader has flip back and forth in the manual to follow what is going on.

In all, the documentation probably is adequate for the experienced programmers targeted by WFC/WFD. It is usable, and products with worse documentation are on the market.

VCS provides technical support via telephone and via BIX, the computer conferencing system operated by *Byte* magazine. Support is not charged separately, but VCS does not have an 800 number. The support people were knowledgeable and promptly able to answer questions put to them. Full source for WFD and WFC is available at extra cost. The company is to be commended for its openness.

Although WFD and WFC may not be redistributed, applications built with them and containing their library functions may be redistributed without royalties or fees. VCS also licenses these two products for use in constructing other programmer tools without royalties, so long as the tool constructed does not compete with them.

WFD and WFC together are a strong but not a perfect combination. Current versions of these products do have several limitations.

WFC is not quite a full virtual window system. An application can have pop-up windows that overlap older windows, and the screen contents are correctly restored when the pop-up window is removed. However, the application must not perform any operations on the lower windows when they are obscured because functions do not always operate correctly on obscured windows, and neither WFD nor WFC give warning when this happens.

The WFD and WFC memory files work well, but they are limited to memory. Although forms and menus may be larger than the window containing them, they also must reside in the available memory. As a consequence, there is a practical limit imposed on the size of the application menu structures, and field-processing applications such as database browsing therefore cannot be implemented.

The approach taken by WFD of integrating generated form code, menu text, and help screen text into the application program is not so flexible as the more modern approach of parameterizing this information into data files that may be modified with little or no impact on the application logic. Such an approach would facilitate multilingual applications.

The forms that are used by WFD are built by using the function calls that are written into the application, with the form-design utility generating the C code. That makes the content and text of the form part of the program. This is a nuisance in some applications, especially ones in which help screens, menus, and forms must be translated into several languages.

This obstacle can be worked around. For instance, the application designer will need to program the management of the screen image data,

rather than have WFD and WFC perform this role. The current version of WFC/WFD has functions to move window images to and from disk, so the programmer can include different windows for different languages. This method is not so clean as keeping the form contents in a separate data file, however, and it constitutes a lot more work for the programmer.

It is hard for the application program to manage help text that is too large to bring into memory in one chunk. The problem, again, is the memory-resident memory files. When a form is activated, all the help text for all the fields must be in memory, regardless of whether it will be used. The alternative is for the programmer to prepare a series of help files and write code to swap them explicitly into memory as called. WFD is better at this task than WFC, but it still requires that all of the help text be kept in memory, unless the application program manages the swapping of help files between the disk and memory.

Finally, WFD and WFC make up a very large package. This occupies 40 to 60KB in the application program, plus memory dynamically allocated for forms, text, and memory files. For Microsoft C, the libraries provided total 700KB, and the header files total over 100KB, which increases compile and link times noticeably but not unacceptably. The many functions and large header files may generate symbol tables that are too large for the Microsoft Codeview debugger to handle. This is a Codeview problem rather than WFC's, and solutions to it exist; however, it remains a question to be considered for large applications.

Since both the forms package and the basic window system were written by the same company, they are unusually well integrated.

Although the package has a number of definite limitations, many of them can be avoided or corrected by the applications developer if this is absolutely necessary. According to VCS, some of these shortcomings will be overcome in future versions.

The Windows for Data and Windows for C package from VCS is one of the first and among the most powerful of packages for controlling windows applications. Although this is not a package for novices, it is, nonetheless, invaluable to the professional who is willing to devote time to learning it.

—PAUL SCHAUBLE and RICK COOK

RICHARD L. SCHWARTZ and ROBERT E. SHOSTAK

## EXPERT CONSULTANT: Applied AI

# AI Search Techniques

*Heuristic search techniques can solve problems in a variety of applications—from planning bike routes to playing board games to powering expert systems.*

The modeling of human problem-solving is one of the oldest and most interesting areas of AI research. Most of the effort researchers have applied to this area has been focused on a particular set of techniques known as *heuristic search*. The word "heuristic" derives from a Greek word meaning "serving to discover." It refers to a hunch, trick, or rule of thumb that usually works, but is by no means guaranteed to do so. The problem of searching for a goal within a large space of possibilities underlies a broad range of problem-solving applications, from planning robot movements to board game strategy. Heuristic search techniques also can be applied to performing AI searches.

Almost any kind of human problem-solving endeavor you can think of can be cast as a search problem, from solving crosswords to choosing your next date. In a sense, even creating art can be viewed as a search problem. Theoretically, an artist could produce a portrait by programming a computer to generate every possible scene on a color graphics display. He would need only press a function key when a good-enough likeness of his subject came up. In AI parlance, this technique of generating all possible alternatives and selecting the first satisfactory one found is known as the *British Museum* procedure. The name facetiously refers to an imaginary tour that visits all of the exhibits in this vast museum. While this simple approach is quite viable for small problems, such as choosing from a menu of ice cream flavors, it is clearly unsatisfactory for larger ones. For example, the artist at his graphics console would need to be satisfied with extremely abstract portraits, to say the least.

The way humans and machines actually go about solving search problems of any size involves two key steps—*ordering* the search so that the most likely alternatives are explored first, and then *pruning* away alternatives that either can be rejected out of hand or seem so unlikely to bring success that they might as well be rejected. Of course, the trick is to figure out how to identify likely and unlikely alternatives. In most cases, the best one can do is to use heuristic search methods, as described below.

### CHOOSING THE BEST PATH

As an example of heuristic search, suppose we wished to find the shortest bicycle route from city *A* to city *Z* on the network shown in figure 1. The cities shown on the network are referred to as *nodes*, while the roads connecting them are called *edges*. Each edge is labelled with a distance, or *cost*.

The most straightforward way of finding the shortest route is simply to trace all possible paths from *A* to *Z*, and compute the distances for each by summing the costs along each path. If we programmed a computer to do the tracing for us, we would need to use some kind of bookkeeping method to keep from looping around in cycles (such as the path *A-B-E-F-C-A*). These cycles can be eliminated by converting the net into a *tree*, as shown in figure 2. The tree is obtained by tracing each path from *A* until it either reaches the goal or revisits a previously traced node. Node *A* is said to be the *root* of the tree. The terminal nodes at the bottom of the tree are called *leaves*.

If the network is of any size, or if we want to minimize the time needed to find a good route, it may be impractical to trace out the entire search tree. Instead, we might be satisfied to explore only those paths that are likely to result in short routes, at the sacrifice of a guarantee that we necessarily will find the absolute shortest. One simple strategy for this approach, called *hill climbing*, entails tracing out a single path from the root, picking the edge labeled with the smallest distance at each branch point. If we come to a dead end before reaching the goal node, *Z*, we backtrack to the last node visited and pick the next best edge. If we have exhausted all the edges from that node, we backtrack to the previous node, and so on. Eventually we must arrive at the goal node. Figure 3 shows the evolution of the path found using hill climbing in our example. The number at the bottom of each partial path gives the cumulative cost of the path. Hill climbing is an instance of a

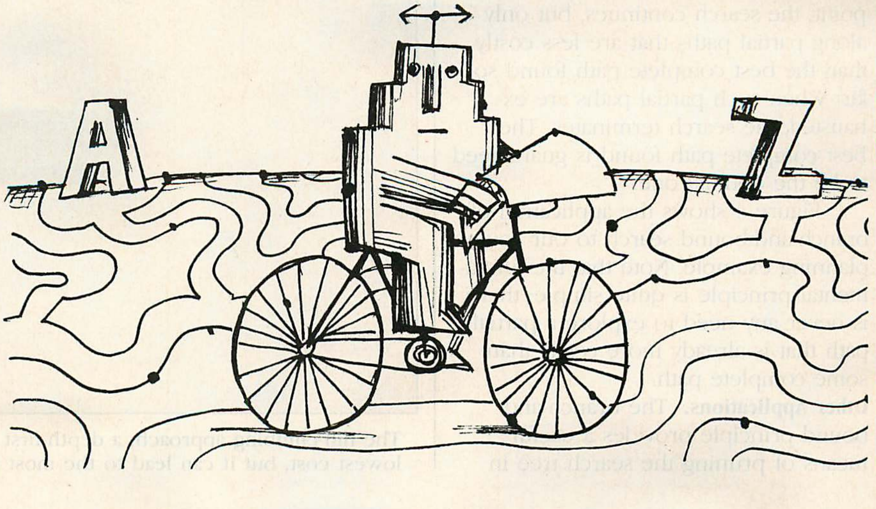
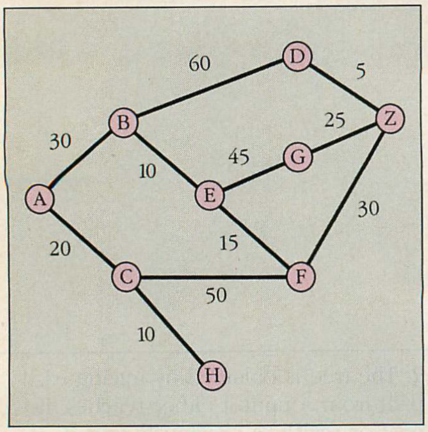



ILLUSTRATION • MACIEK ALBRECHT

**FIGURE 1:** ***Bike-tour Map***




The map shows all possible routes from city *A* to city *Z*, and the distances between cities in the network.

*depth-first search*, so called because the nodes at deeper levels of the tree are explored before those at the same level as the current node.

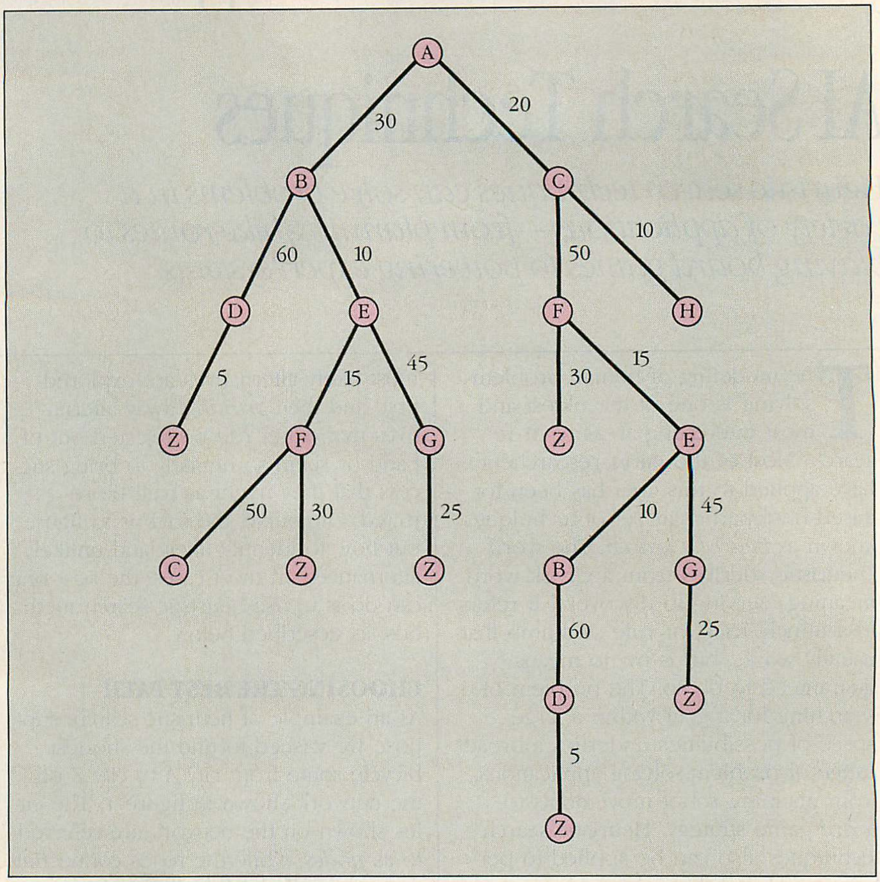
Note that the path picked by the hill-climbing approach is far from the shortest (in fact, it is the longest!), because the cheapest-edge heuristic myopically forces choices that turn out to be poor in the long run. This penny-wise, pound-foolish effect, called the *foothill problem*, is characteristic of hill climbing and other depth-first approaches. (Of course, bicyclists take a dim view of hill-climbing in any case.)

The foothill problem can be avoided using a breadth-first approach, known as *branch-and-bound*. The basic idea is to work simultaneously on several partial paths from the root, keeping track of the cumulative cost along each. At each step, the partial path that currently has the least cost is extended one more level in the tree. Eventually, the goal node will be reached along some path, completing that path. At this point, the search continues, but only along partial paths that are less costly than the best complete path found so far. When such partial paths are exhausted, the search terminates. The best complete path found is guaranteed to be the optimal one.

Figure 4 shows the application of branch-and-bound search to our route-planning example. Note that the fundamental principle is quite simple: there is never any need to explore a partial path that is already more costly than some complete path.

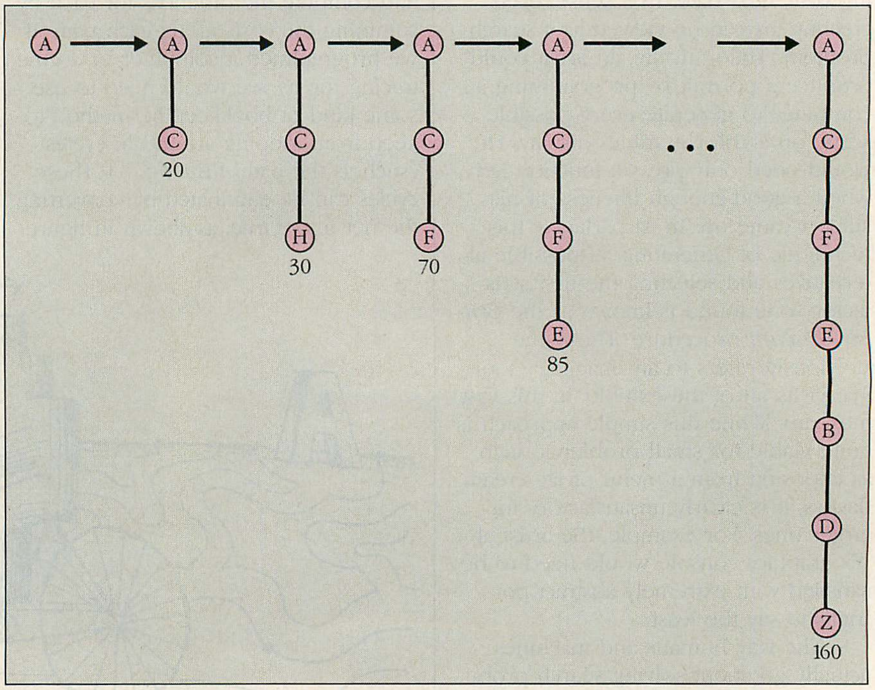
**Other Applications.** The branch-and-bound principle provides a useful means of pruning the search tree in

**FIGURE 2:** ***Search Tree for Bike-tour Problem***



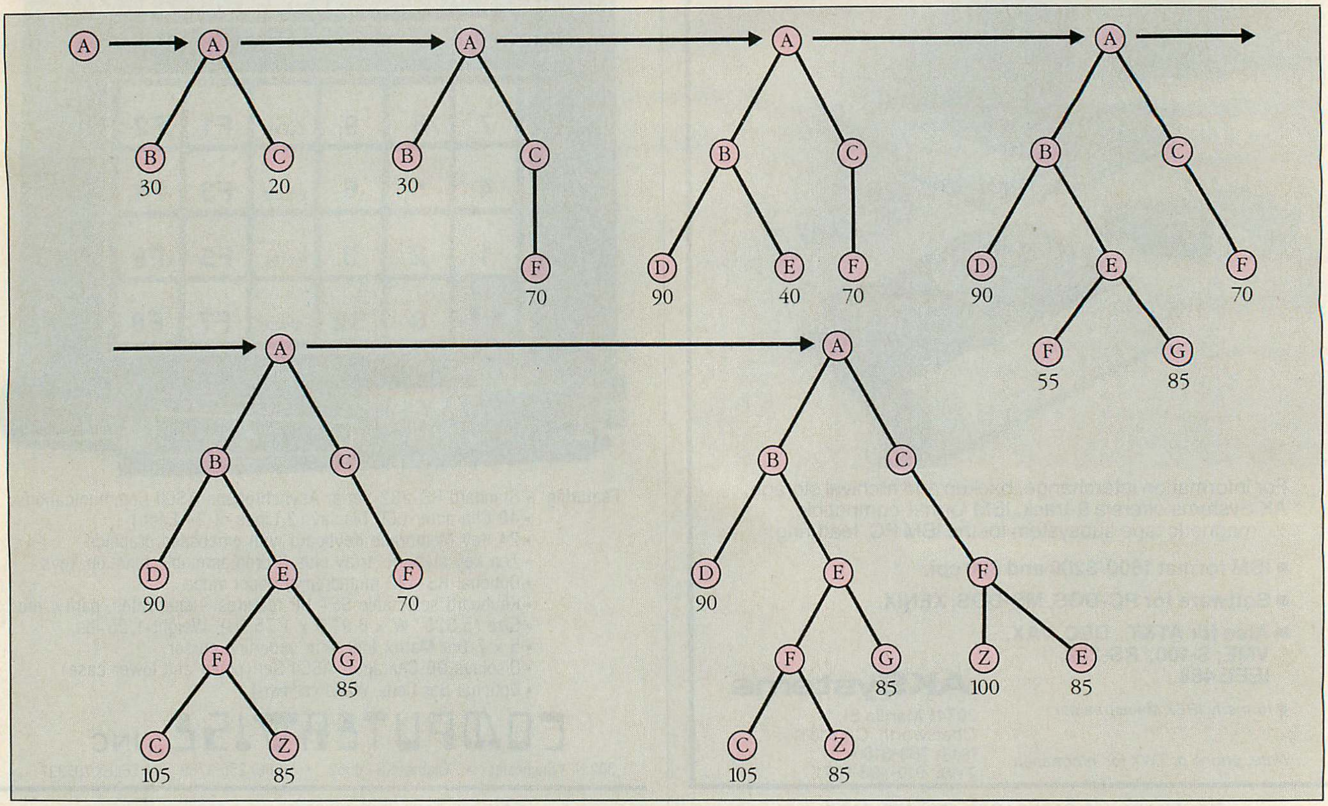
A search tree is created by tracing each path from *A* to the goal node, *Z*, or until a node is revisited. The tree prevents cycling over the same path.

**FIGURE 3:** ***Hill-climbing Solution to Bike-tour Problem***




The hill-climbing approach, a depth-first strategy, makes choices based on the lowest cost, but it can lead to the most costly route in the long run.

**FIGURE 4:** ***Branch-and-bound Solution to Hill-climbing Problem***




The branch-and-bound approach is a breadth-first strategy that works on several paths simultaneously. This approach allows comparison of all possible paths at the same level in the tree so that the least costly, best path can be selected.

many different contexts, including non-AI ones such as integer linear programming. Among the better known applications is analyzing search trees for two-player games, such as chess. Here, the edges at even depths of the tree represent moves by one of the players, while edges at odd depths represent moves by the other player. A modification of the branch-and-bound principle called *alpha-beta pruning* is used to search for a best move.

Another application for heuristics is in expert systems, which draw inferences and reach conclusions from information that is either stored internally or in a data base or entered interactively by a user. Search strategies are of paramount importance in the inference engine of expert systems. The engine must pick its way through a large number of facts to solve a problem. The more efficient the search, the faster the answer will be returned. The expert system heuristically applies hunches or rules of thumb to search for the best solution.

*Richard L. Schwartz, Ph.D., and Robert E. Shostak, Ph.D., are vice presidents of development and cofounders of Ansa Software.*

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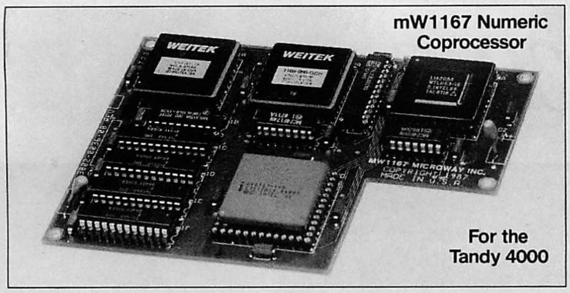


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THE COMPREHENSIVE GUIDE TO PRODUCTS AND SERVICES FOR THE MS DOS MARKET

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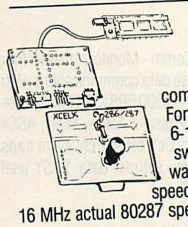

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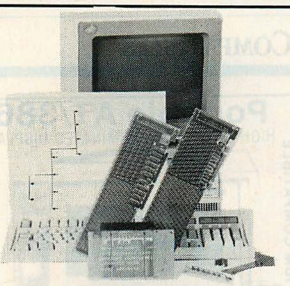

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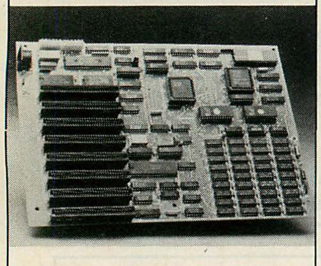

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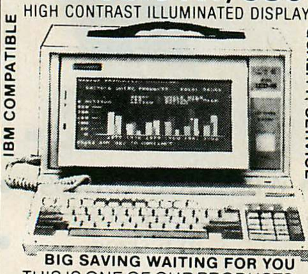

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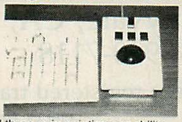

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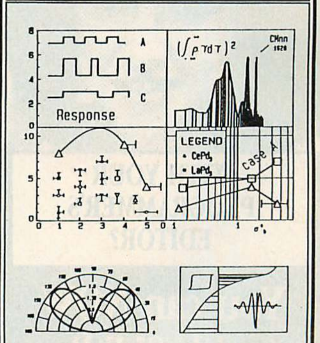


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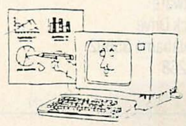

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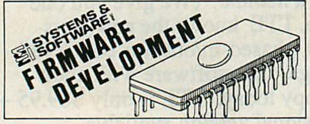


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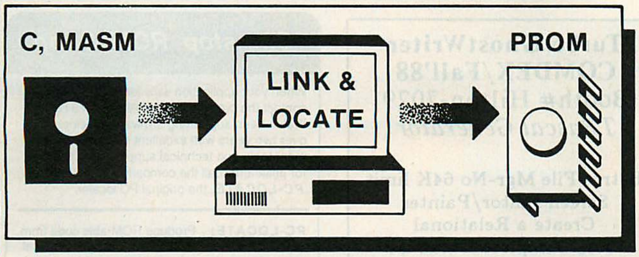


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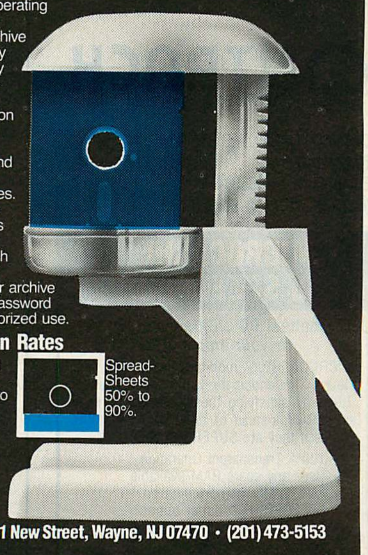

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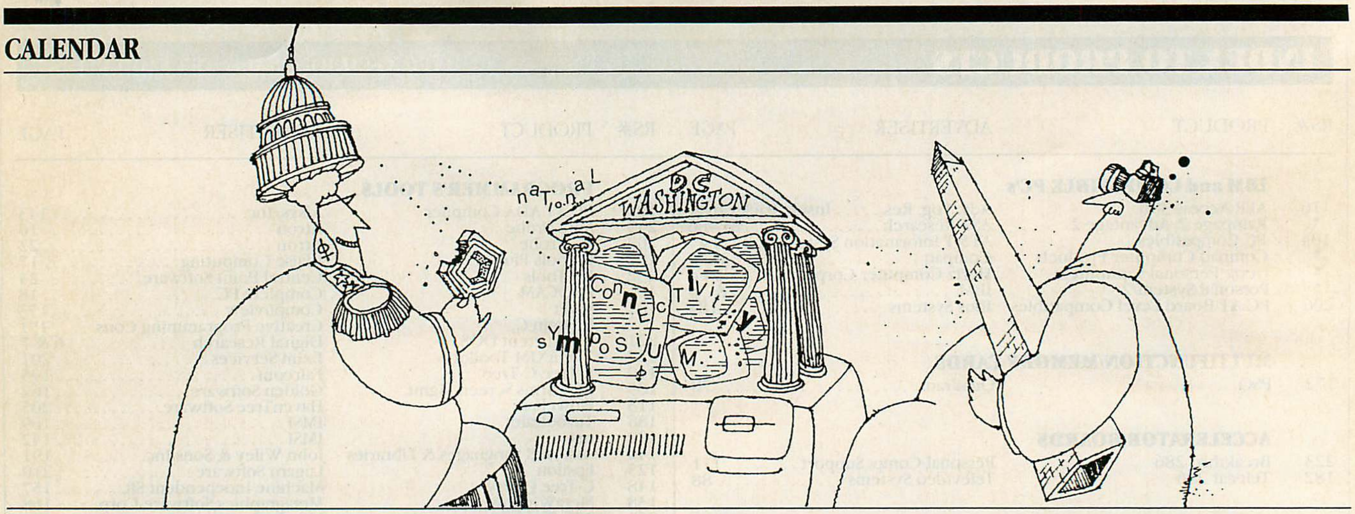


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***December 1–3***
**Optical Information Systems '87**
New York, NY (Conference Management Corporation) *Contact:* Meckler Publishing, 11 Ferry Lane W, Westport, CT 06880; 203/226-6967

***December 6–9***
**International Conference on Information Systems**
Pittsburgh, PA (Society for Information Management) *Contact:* William D. King, Graduate School of Business, University of Pittsburgh, Pittsburgh, PA 15260; 412/648-1587

***December 7–8***
**Fault Tolerance in Parallel and Distributed Computing**
San Diego, CA (IEEE-CS) *Contact:* Prof. Miroslan Malek, Dept. of EE and CE, University of Texas, Austin, TX 78712; 512/471-5704

***December 7–9***
**National Connectivity Symposium on LANs and Links**
Washington, DC (Digital Consulting, Inc.) *Contact:* Seminar Services, 6 Windsor Street, Andover, MA 01810; 617/470-3880

***December 14–16***
**1987 Winter Simulation Conference**
Atlanta, GA (IEEE-CS) *Contact:* Hank Grant, Factrol, Inc., 1305 Cumberland Avenue, P.O. Box 2569, West Lafayette, IN 47906; 317/463-5559

***December 16–18***
**Microcomputer Graphics '87**
New York, NY (Expoconsul International) *Contact:* Expoconsul International, Inc., 3 Independence Way, Princeton, NJ 08540; 609/987-9400

## JANUARY

***January 5–8***
**Hawaii International Conference on System Sciences**
Kailu-Kona, HI (IEEE-CS) *Contact:* Ralph H. Sprague, Jr., Decision Sciences Dept., University of Hawaii, 2404 Maile Way, E-303, Honolulu, HI; 808/948-7430

***January 10***
**Optoelectronics and Laser Applications**
Los Angeles, CA (SPIE) *Contact:* Jane Lybecker, SPIE, P.O. Box 10, Bellingham, WA 98227; 206/676-3290

***January 13–15***
**Design Automation Workshop**
Appache Junction, AZ (IEEE-CS) *Contact:* Walling Cyre, Control Data, HQM 173, P.O. Box 1249, Minneapolis, MN 55440; 612/853-2692

## FEBRUARY

***February 1–5***
**International Conference on Data Engineering**
Los Angeles, CA (IEEE-CS) *Contact:* Benjamin W. Wah, Dept. of EE and CE, University of Illinois, Urbana, IL 61801; 217/333-3516

***February 8–11***
**UniForum '88**
Dallas, TX (The International Network of UNIX Users) *Contact:* UniForum '88, 2400 E. Devon Avenue, Suite 205, Des Plaines, IL 60018; 800/323-5155; 312/299-3131

***February 16–18***
**DEXPO East '88 Conference**
New York, NY (Expoconsul International) *Contact:* Expoconsul International, Inc., 3 Independence Way, Princeton, NJ 08540; 609/987-9400

***February 22–24***
**Computer Graphics New York**
New York, NY (Exhibition Marketing and Management, Inc.) *Contact:* EMM, Inc., Inc., 8300 Greensboro Drive, Suite 1110, McLean, VA 22102; 703/893-4545

***February 23–25***
**Computer Science Conference on Software**
Atlanta, GA (ACM) *Contact:* Dr. Richard A. DeMillo, Program Chairman, Software Engineering Research Center, Georgia Institute of Technology, Atlanta, GA 30332; 404/894-3180

## MARCH

***March 8–10***
**Technical Conference for MIS/DP Professionals**
New York, NY (Cahners Exposition Group) *Contact:* Cahners Exposition Group, 999 Summer Street, Stamford, CT 06905; 203/964-0000

***March 8–11***
**International Symposium on Digital Communications**
Zurich, Switzerland (IEEE-CS) *Contact:* Secretariat 1ZS 88, c/o P. Gunzburger, Hasler AG, TDS, Belpstrasse 23, CH-3000, Bern 14, Switzerland; 41-31-632808

***March 10–11***
**APPC Communication**
San Francisco, CA (Systems Technology Forum) *Contact:* Sherry Armstrong, seminar coordinator, Systems Technology Forum, 10201 Lee Highway, Suite 150, Fairfax, VA 22030; 800/336-7409; 703/591-3666

***March 20–24***
**NCGA Annual Conference**
Anaheim, CA (National Computer Graphics Association) *Contact:* NCGA, 2722 Merrilee Drive, Suite 200, Fairfax, VA; 703/698-9600

***March 21–23***
**Computer Standards Evolution**
Arlington, VA (IEEE-CS) *Contact:* Computer Standards Conference, IEEE, 1730 Massachusetts Avenue NW, Washington, DC 20036-1903; 202/371-0101

***March 21–25***
**World Users Conference**
Los Angeles, CA (MacNeal-Schwendler Corporation) *Contact:* MacNeal-Schwendler, 815 Colorado Blvd., Los Angeles, CA 90041; 213/258-9111

***March 23–25***
**Extending Database Technology**
Venice, Italy (IEEE-CS, IASI, and INRA) *Contact:* Prof. Stefano Ceri, Politecnico di Milano, Dipart. di Elektronika, Piazza Leonardo da Vinci 32, 20133 Milano, Italy; 02-2367241

***March 28–31***
**World Congress on Computing**
Chicago, IL (Interface Group) *Contact:* The Interface Group, Inc., 300 First Avenue, Needham, MA 02194; 617/449-6600

***March 29–31***
**Conference on Optical Storage of Documents and Images**
Washington, DC (Rothchild Consultants) *Contact:* Rothchild Consultants, 256 Laguna Honda Blvd., San Francisco, CA 94116-1496; 415/681-3700

## APRIL

***April 11–13***
**Networking Symposium**
Arlington, VA (IEEE-CS) *Contact:* George K. Chang, 6 Corporation Place, Piscataway, NJ 08854; 201/699-3879

***April 11–15***
**International Conference on Software Engineering**
Raffles City, Singapore (IEEE-CS, NCB, and ACM) *Contact:* Tan Chin Nam, 71 Science Park, Singapore 0511; 65/772-0200

***April 25–28***
**International Conference on Expert Database Systems**
Tysons Corner, VA (George Mason University) *Contact:* Edgar H. Sibley, GMU, ICSE Department, 4400 University Drive, Fairfax, VA 22030; 703/323-2779

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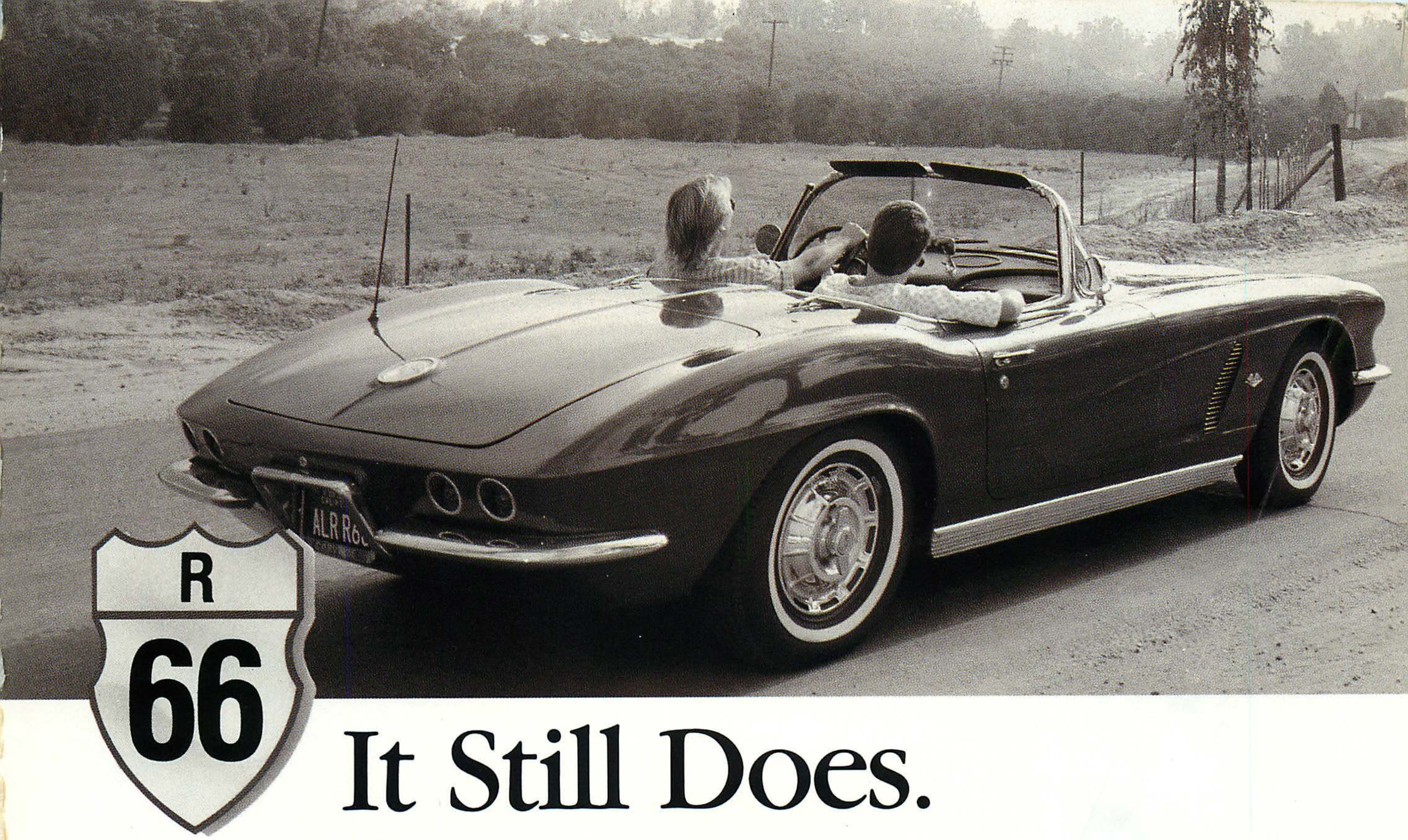

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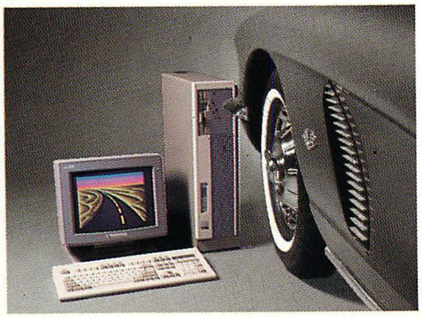
## Introducing R66™ Systems from Advanced Logic Research: 286 or 386 Fast, 66 MB Big.

### Get Your Kicks on an R66.

Route 66, America's first transcontinental highway, inaugurated an exciting new way to travel—hurling down the road at wide-open speed, through wide-open space. Now, the spirit of Route 66 lives on with the introduction of Advanced Logic Research R66 systems.



Speed along with the Dart™ R66, a fast 10-MHz 286-based system, or really peel out with the ALR 386/2™ R66, a still faster 386-based system. And to make sure all that horsepower has room to run, both R66 systems include a speedy 66-MB, 28-ms hard disk.

Even better, R66 systems give you all this high performance computing power at about half the price of other comparable machines. For instance, compare the Dart R66 to the IBM PS/2™ Model 60 and AST Premium/286™ Model 140. They all share the same 10-MHz 80286 processor, which offers compatibility with IBM's OS/2, the newest generation of more powerful multitasking software. And they all feature the same first-rate design and first-class components. Yet the R66 still costs as little as half as much.

### Break the Speed Limit.

In computing, like cross-country travel, speed is of the essence. And R66 systems deliver the power to take you wherever you want to go. Fast.

But to get outstanding PC performance, it takes more than just an 80286 or 80386 processor. Which is why every component in R66 systems is carefully designed for maximum overall system speed.

| | ALR Dart R66 | ALR 386/2 R66 | IBM PS/2 Model 60 | AST Premium/286 Model 140 |
|---|---|---|---|---|
| Price | $2295 | $3490 | $5295 | $3495 |
| Microprocessor | 10-MHz 80286 | 16-MHz 80386 | 10-MHz 80286 | 10-MHz 80286 |
| Hard disk | 66 MB, 28 ms | 66 MB, 28 ms | 44 MB, 40 ms | 44 MB, 28 ms |
| Data transfer rate | 390 KB/s | 390 KB/s | 255 KB/s | 255 KB/s |
| Interleaving | 1:1 | 1:1 | 1:1 | 2:1 |
| RAM | 1 MB, expandable to 2 MB on system board | 1 MB, expandable to 2 MB on system board | 1 MB | 1 MB |
| Coprocessor support | 80287 | 80287 and 80387 | 80287 | 80287 |
| Serial/parallel ports | 2/2 | 1/1 | 1/1 | 1/1 |

For example, R66 hard disks are rated at 28 ms average access time, 30% faster than the IBM Model 60. And R66 hard disks use 1:1 interleave for even faster disk operation, unlike AST's hard disk. R66 systems also transfer data from disk to memory at a scorching 390 KB/s, a full 50% faster than the other machines. The result? Fewer processing bottlenecks and faster system performance.

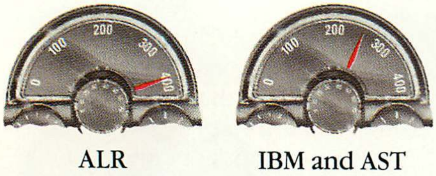
### Soup Them Up.

If you're working on arithmetic-intensive graphics or database applications, the Dart R66 is socketed for 80287 coprocessor support, and the ALR 386/2 R66 is socketed for both 80287 and 80387 coprocessors.

And if you need the ultimate in flat-out speed, ask about the ALR 386/2 R66 equipped with 20-MHz processor speed.

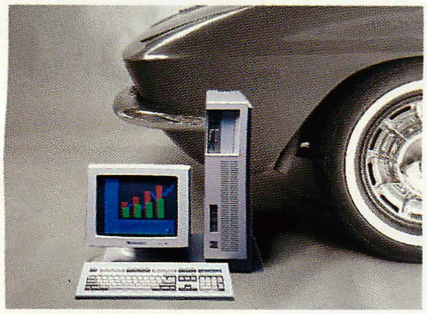
### Room to Roam.

Advanced Logic Research R66 systems come with a 66-MB hard disk that's a full 50% larger than the ones you'll find on IBM and AST's machines. So you'll have half again as much disk space to spread out in.




*With a 50% faster transfer rate from disk to memory, R66 systems are just the ticket for high speed, disk-intensive computing.*

And speaking of more space, since the system board has room for an extra 1 MB of RAM in addition to the 1 MB already installed, memory expansion doesn't have to mean fewer available expansion slots.



*With its combination of processing power and disk space, R66 systems are ideal for graphics applications like CAD/CAM and desktop publishing.*

## Born to Run. And Run.

When it comes to designing high performance systems, there's no substitute for experience. Which is why you'll be glad to know that Advanced Logic Research has introduced more high performance IBM-compatible computer models than anyone. Including the first fully-developed 80386 computers ever.

That gives us the confidence to back ALR-manufactured products with a one-year limited warranty—your guarantee that Advanced Logic Research systems deliver high performance and high reliability.

## Take a Test Drive Today.

If you're yearning for more speed, more room, or both, then test-drive an R66 system at your nearby Advanced Logic Research dealer, one of over 700 nationwide.

In addition to R66 systems, you'll also see the largest line of high performance PC systems available anywhere. Plus all the Advanced Logic Research enhancements you'll need, including additional memory, graphics adapters, and communications equipment.


Get the name of the nearest Advanced Logic Research dealer by calling (714) 581-6770. Then get behind an R66 system and discover the difference that extra speed to burn and room to play can make.

## Specifications

### Dart R66 $2295

- ALR-designed multilayer system board
- 80286-10 microprocessor
- Socketed for 80287 support
- 1 MB RAM, expandable to 2 MB on system board
- 66-MB, 28-ms hard disk drive
- 1.2-MB, 5 1/4-inch floppy disk drive; 3 1/2-inch drives optional
- Two serial and two parallel ports
- Phoenix BIOS
- Optional EMS software
- Eight expansion slots
- Floormount configuration
- 101-key keyboard
- Shown with optional graphics adapter and monitor

### ALR 386/2 R66 $3490

- ALR-designed multilayer system board
- 80386-16 microprocessor, 20-MHz CPU speed optional
- Socketed for 80287 and 80387 support
- 1 MB 32-bit, 80-ns RAM, expandable to 2 MB on system board
- 66-MB, 28-ms hard disk drive
- 1 serial, 1 parallel port
- Phoenix BIOS
- 32-bit control software: Vdisk, disk caching, EMS and EEMS (optional)
- 1.2-MB, 5 1/4-inch floppy disk drive, 3 1/2-inch drives optional
- Eight expansion slots
- Floormount configuration
- 101-key keyboard
- Shown with optional graphics adapter and monitor

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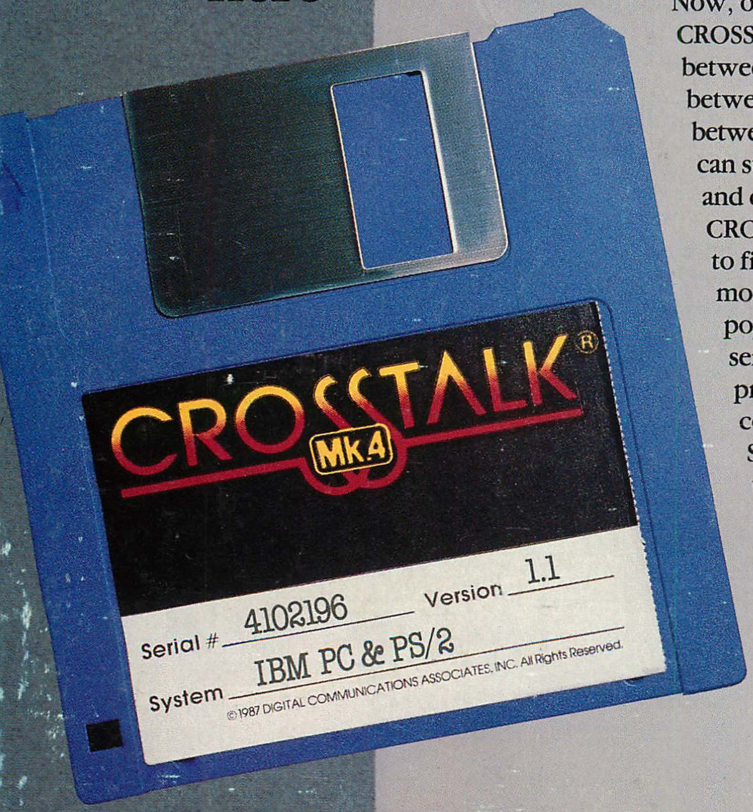


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